FINAL REPORT:
Integrated Ecosystem Model for Alaska and Northwest Canada Project

A collaborative project of the Alaska Climate Science Center and the Arctic, Western Alaska, and Northwest Boreal Landscape Conservation Cooperatives

Zak Richter/NPS

September 1, 2011 - August 31, 2016

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Suggested citation:

McGuire, A.D., T.S. Rupp, A. Breen, E.S. Euskirchen, S. Marchenko, V. Romanovsky, A. Bennett, W.R. Bolton, T. Carman, H. Genet, T. Kurkowski, M. Lara, D. Nicolsky, R. Rutter, & K. Timm. (2016). Final Report: Integrated Ecosystem Model (IEM) for Alaska and Northwest Canada Project. Fairbanks, AK; Scenarios Network for Alaska and Arctic Planning. 71 pages. doi: http://doi.org/10.21429/C9RP43

Download a PDF of this report at: https://www.sciencebase.gov/catalog/item/5841f304e4b04fc80e518d56

Access data described in this report: https://www.snap.uaf.edu/projects/iem

The project described in this publication was supported by the Alaska Climate Science Center's Cooperative Agreement Number G10AC00588 and G11AC20291 from the United States Geological Survey. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the USGS.

ABBREVIATIONS & ACRONYMS

A1B	A mid-range emissions scenario
A2	A high-range emissions scenario
ACP	Arctic Coastal Plain
AK CSC	Alaska Climate Science Center
ALFRESCO	Alaska Frame-Based Ecosystem Code
ALT	Active Layer Thickness
APEX	Alaska Peatland Experiment
AR4	IPCC Fourth Assessment Report
AR5	IPCC Fifth Assessment Report
ATM	Alaska Thermokarst Model
B2	A low-range emissions scenario
C	Carbon
CAVM	Circumpolar Arctic Vegetation Model
CCCMA CGCM3 (T47)	General Circulation Model version 3.1-t47, developed at the Canadian Centre for Climate Modeling and Analysis (CCCMA)
CCSM4	Community Earth System Model 4, developed at the National Center for Atmospheric Research (NCAR)
CH_4	Methane
CMIP	Coupled Model Intercomparison Project
CMIP3	Coupled Model Intercomparison Project - Phase 3
CMIP5	Coupled Model Intercomparison Project - Phase 5
CO_2	Carbon Dioxide
CRU	Climate Research Unit
DOS-TEM	Dynamic Organic Soil version of the Terrestrial Ecosystem Model
DVM-DOS-TEM	Dynamic Vegetation Model/Dynamic Organic Soil Version of the Terrestrial Ecosystem Model
DWD	Dead Woody Debris
ECHAM	European Centre Hamburg Model 5, developed at the Max Planck Institute for Meteorology
ER	Ecosystem Respiration
FMPO	Fire Management Planning Option
GCM	General Circulation Model
Gen 1	Generation 1 or linear coupling of the IEM where exchange of information between models occurs in series

Gen 2	Generation 2 or cyclical coupling of the IEM where data outputs are exchanged among all models, which produce outputs at different time scales, and incorporates the outputs for the next time step
GIPL	Geophysical Institute Permafrost Lab model
GIS	Geographic Information System
GPP	Gross Primary Production
IEM	Integrated Ecosystem Model or Integrated Ecosystem Model for Alaska and Northwest Canada
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
LCC	Landscape Conservation Cooperative
LTER	Long Term Ecological Research Network
MAGT	Mean Annual Ground Temperature
MDM	Methane Dynamic Model
MOSSDZ	Thickness of the moss layer
MPI-ECHAM5/MPI-OM	Max Planck Institute for Meteorology, European Centre Hamburg Model 5
MRI-CGCM3	Meteorological Research Institute, Coupled General Circulation Model v3.0
N	Nitrogen
NCAR	National Center for Atmospheric Research
NEE	Net Ecosystem Exchange
NPP	Net Primary Productivity
PDOS-TEM	Peatland Dynamics Organic Soil version of the Terrestrial Ecosystem Model
PI	Principal Investigator
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RCP	Representative Concentration Pathways
RH	Heterotrophic Respiration
RPM	RPM Package Manager
SERDP	Strategic Environmental Research and Development Program
SNAP	Scenarios Network for Alaska and Arctic Planning
SOILC	Change in soil carbon stocks
SOC	Soil Organic Carbon
SPOT-5	Satellite Pour l'Observation de la Terre number 5
TEM	Terrestrial Ecosystem Model
TK	Thermokarst
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
VEGC	Vegetation Carbon Stocks

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SECTION 1.
SUMMARY

This report describes the progress made by the Integrated Ecosystem Model (IEM) for Alaska and Northwest Canada Project for the full duration of the project (September 1, 2011 through August 31, 2016). The primary goal of this project was to develop the IEM modeling framework to integrate the driving components for and the interactions among disturbance regimes, permafrost dynamics, hydrology, and vegetation succession/migration for Alaska and Northwest Canada. The major activities of the project include (1) development and delivery of input data sets, (2) model coupling, (3) evaluation and applications of fire and vegetation dynamics, (4) evaluation and application of ecosystem carbon and energy balance, (5) evaluation and application of regional permafrost dynamics, (6) permafrost infrastructure modeling research, (7) development of a landscape thermokarst modeling capability, and (8) development of wetland modeling capability based on field studies. Here we briefly describe the key accomplishments for each of the major activities of the project as well as a summary of next steps for each of the major activities.

INPUT DATA SET DEVELOPMENT AND DELIVERY

We completed two separate global circulation model selection procedures to determine the best performing models over the IEM region. We downscaled all IEM input variables to the appropriate model resolution of 1km. To deal with the high level of natural year to year variability in wildfire, we determined which climate model inputs would result in the most and least area burned over time when ran through the ALaska FRame-based EcoSystem COde (ALFRESCO) fire model. This approach allowed us to explore the full range of likely future projections of fire. We developed an initial set of specific climate summaries and change geographic information system (GIS) datasets showing how climate models compare through time and to historical data. We also developed a more user friendly data publishing platform. Our analysis indicates that in the last 60 years, Alaska has seen a large increase in mean annual air temperature (1.7 °C), with the greatest warming occurring over winter and spring. Warming trends are projected to continue throughout the 21st Century.

MODEL COUPLING

To allow individual modeling groups to continue to control the source code for the independent models, a common "coupling" environment was designed to handle the time series control and data sharing among models. Individual models were compartmentalized to support modular use, so that the framework could be run as an integrated model, or as independent models. Common data is passed through the coupler to prevent extensive input/output slowdowns for temporary state data. The coupler executable was developed and tested, and continues to be modified as component models make additional progress towards integration. Currently, the modeling coupling framework supports time step synchronization, data sharing and storage, with individual models handling specific changes. To support the computational and storage requirements of the IEM, a computing cluster was purchased, installed, and configured.

FIRE AND VEGETATION DYNAMICS

The ALFRESCO model was used to simulate the dynamics of wildfire and vegetation transitions for historical (1950-2009) and future (2010-2100) time periods across the IEM domain driven by two climate scenarios that resulted in substantial differences in the simulated area burned. Fire frequency and area burned have increased in recent years across Alaska and northwest Canada, and the trend is projected to continue for the rest of the century for both climate models. The boreal region is projected to see the highest increase in fire activities, and late successional vegetation in the region, such as spruce forest, was projected to decline, whereas early to mid-successional vegetation, such as deciduous forest, was projected to increase. In tundra regions, shrub tundra is generally projected to increase and graminoid tundra to decrease.

ECOSYSTEM CARBON DYNAMICS AND ENERGY BALANCE

We further developed Dynamic Organic Soil version of the Terrestrial Ecosystem Model (DOS-TEM) to represent the effects of fire severity on carbon storage. We applied DOS-TEM, driven by the wildfire outputs of ALFRESCO, over the entire IEM domain. Carbon dynamics were simulated by DOS-TEM at 1-km resolution, with dynamic climate and fire regime, and static vegetation composition. These simulations were a key aspect of the USGS Land Carbon Project. Changes in atmospheric heating were estimated for each Landscape Conservation Cooperative (LCC) region in Alaska using snow cover from DOS-TEM, and fire and vegetation dynamics from ALFRESCO. The model simulations indicate that the IEM region was a small sink for carbon during the historical time period and becomes a much stronger sink for carbon in the future. These results of the simulations also indicate that changes in snow cover duration, including both the timing of snowmelt in the spring and snow return in the fall, provided the dominant positive biogeophysical feedback to climate across all LCCs, and were greater for the warmer and drier climate scenario compared to the less warm and dry climate scenario due to more loss of snow cover in the warmer scenario. The greatest overall negative feedback to climate from changes in vegetation cover was due to fire in spruce forests in the Northwest Boreal LCC and fire in shrub tundra in the Western LCC.

PERMAFROST DYNAMICS: REGION-WIDE MODELING RESEARCH

The Geophysical Institute Permafrost Lab (GIPL) model was used to simulate the dynamics of permafrost temperature and active layer thickness, for historical (1901-2009) and future (2010-2100) time periods across the IEM domain. Simulations of future changes in permafrost indicate that, by the end of the 21st century, late Holocene permafrost in Alaska and Northwest Canada will be actively thawing at all locations and that even some Late Pleistocene permafrost will begin to thaw at some locations. The modeling results also indicate how different types of ecosystems and fire disturbances affect the thermal state of permafrost and their stability. Although the rate of soil warming and permafrost degradation in peatland areas are slower than other areas, a considerable volume of peat in Alaska and Northwest Canada will be thawed by the end of the current century.

PERMAFROST DYNAMICS: INFRASTRUCTURE MODELING RESEARCH IN NORTHERN ALASKA

To understand how the potential changes in permafrost will affect infrastructure on local and regional scales, we modeled the ground temperature dynamics using the two climate scenarios representing different levels of warming for disturbed ground conditions. To illustrate this capability, we modeled a potential increase in taliks, which is unfrozen ground material between the bottom of the active layer and the top of the permafrost table, for gravel pads with thickness of 0.6 m (2 ft), 1.2 m (4 ft) and 1.8 m (6 ft). The development of taliks in undisturbed conditions will have serious implications for ecosystems, hydrology, and animal habitats that will impact subsistence lifestyles, while the development of taliks under the gravel pads will impact infrastructure and increase maintenance expenses.

THERMOKARST MODELING

The development of a thermokarst model capable of predicting landscape-level dynamics of thermokarst disturbance across the IEM domain was a major research effort in this phase of the IEM effort. Changes to the structure and function of wetlands has the potential to affect animal species that are dependent on these wetland complexes. As part of this research, we successfully developed a conceptual framework for the Alaska Thermokarst Model (ATM) in the context of the IEM as a stand-alone state-and-transition module that simulate landscape transitions for thermokarst landforms analogous to ALFRESCO's simulation of vegetation dynamics. We also developed a permafrost predisposition model to estimate the portion of the landscape vulnerable to thermokarst disturbance. We have developed the transition rules for both tundra and boreal ecosystems. We have also developed a land cover for the arctic coastal plain of Alaska to be used by the ATM. Wetland Dynamics: Field-based Research. We continued our collaboration with Dr. Waldrop's (USGS Menlo Park) field program studying wetland dynamics. These field studies consist of conducting flux scaling studies at the Alaska Peatland Experiment (APEX), where work has been ongoing since 2005. Data from the eddy covariance sites indicate that the net ecosystem exchange of a rich fen, thermokarst collapse scar bog, and black spruce forest is sensitive to hot, dry conditions. We find large amounts of interannual variability in net ecosystem exchange at the thermokarst collapse scar bog, ranging from a source of 126 g C m-2 in 2014 to a sink of -83 g C m-2 in 2012. Methane emissions varied across the sites, with largest emissions of CH_4 in the rich fen and collapse scar bog and little from the black spruce forest. Studies of N availability indicate that the conversion of forest to wetlands associated with permafrost thaw in boreal lowlands increases N availability, at least in part by increasing turnover of deep soil organic matter. Long-term carbon flux data from water table manipulations at the rich fen suggests that there are lag effects of droughts seen in a treatment with a lower water table as carbon fluxes remained suppressed in wet years following prolonged droughts.

WETLAND DYNAMICS: MODELING RESEARCH

The goal of the model-based research of the wetland dynamics activity was to model the biogeochemical and successional dynamics of wetland types in Alaska. We primarily focused on modeling the biogeochemical dynamics of two wetland types being studied as part of the field-based research component of the wetland dynamics activity: (1) collapse-scar fens and (2) collapse-scar bogs. The primary tool we developed as part of this activity was peatland DOS-TEM (PDOS-TEM), which required adding a peatland organic carbon module to DOS-TEM. After developing and integrating this module into PDOS-TEM, we applied the model to synthesize the results of a field water table manipulation experiment that was conducted in a boreal rich fen and in a collapse scar bog, both of which were studied as part of the wetland field program. Our objective in these studies was to use the model to understand how increasing atmospheric CO_2 and changing climate will influence the exchange of CO_2 and CH_4 with the atmosphere, and the degree to which the cumulative forcing of these exchanges would enhance or mitigate climate warming.

PRIORITY NEXT STEPS

Our key goal early in the next phase of the IEM project is to complete the cyclical/synchronous coupling of ALFRESCO, DVM-DOS-TEM, and GIPL in the IEM framework so that feedbacks among the extant versions of these component models are fully considered in the application of the IEM framework. We will conduct research to add new functionality to the IEM framework by the end of the next phase. This includes the implementation of herbivory and associated vegetation dynamics in ALFRESCO, with applications focused on caribou and moose. We will also implement successional vegetation and wetland biogeochemical capabilities into DVM-DOS-TEM. In the next phase of the IEM project, the ATM will be applied outside of the original test areas, in all Interior Alaska and the entire Arctic Coastal Plain. The ATM will also be dynamically coupled to the IEM framework to represent the effect of thermokarst dynamics on hydrology, vegetation composition, permafrost dynamics, biogeochemical and biogeophysical processes. We will also develop animal habitat models capable of using the landscape dynamics simulated by the ATM to assess how thermokarst disturbance may influence the availability of animal habitat.

Project data described in the following sections are available at: www.snap.uaf.edu/projects/iem

SECTION 2.
PREFACE

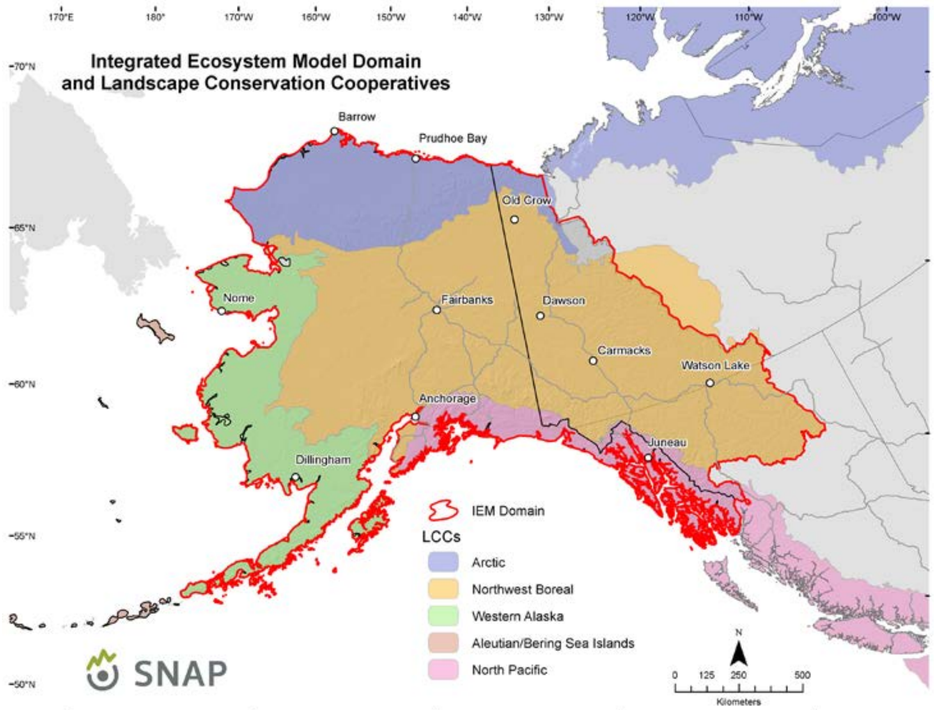


Figure 2-1. The spatial domain of the Integrated Ecosystem Model for Alaska and Northwest Canada.

Ongoing climate change throughout Alaska and Northwest Canada is affecting terrestrial ecosystems and the services that they provide to the people living in the region. These services include the provisioning of food and fiber by Alaskan ecosystems, the importance of ecosystems to recreation, cultural, and spiritual activities of people in the region, and the role Alaska ecosystems play in regulating hydrology and the climate system. Assessments of the effects of climate change on ecosystem services has in part been hindered by the lack of tools capable of forecasting how landscape structure and function might change in response to climate change. In Alaska and Northwest Canada, such tools need to consider how ecological processes play out in both space and time. Landscapes may change in time and space, in part, because of shifting species composition (e.g., an increase of shrubs in tundra) and species migration (e.g., treeline advance). Shifts in landscape structure and function may be caused by changes in disturbance regimes (e.g., fire), permafrost integrity, and hydrology across the landscape. This project developed, tested, and applied the Integrated Ecosystem Model (IEM) for Alaska and Northwest Canada to explore how landscape structure and function might change in response to how climate change influences interactions among disturbance regimes, permafrost integrity, hydrology, vegetation succession, and vegetation migration. This tool provides scenarios of changes in landscape structure and function that can be used by resource-specific impact models to assess the effects of climate change on specific natural resources.

This primary goal in this project was to develop the IEM modeling framework to integrate the driving components for and the interactions among disturbance regimes, permafrost dynamics, hydrology, and vegetation succession/migration for Alaska and Northwest Canada. The geographic domain of the Integrated Ecosystem Model for Alaska and Northwest Canada includes four of Alaska's Landscape Conservation Cooperatives (LCCs, Figure 2-1): Arctic LCC, Western Alaska LCC, Northwest Boreal LCC, and the area of the North Pacific LCC within Alaska. This framework couples (1) a model of disturbance dynamics and species establishment (ALFRESCO), (2) a model of soil dynamics, hydrology, vegetation succession, and ecosystem biogeochemistry (the dynamic vegetation model /dynamic organic soil version of the Terrestrial Ecosystem Model (DVM-DOS-TEM)), and (3) a model of permafrost dynamics (the GIPL model) (Figure 2-2). The IEM is an integrated framework that provides natural resource managers and decision makers an improved understanding of the potential response of ecosystems due to a changing climate and more accurate projections of key ecological variables of interest (e.g., wildlife habitat conditions).

Our specific objectives in this project were to (1) "couple" the models, (2) develop necessary input and desired outputdata

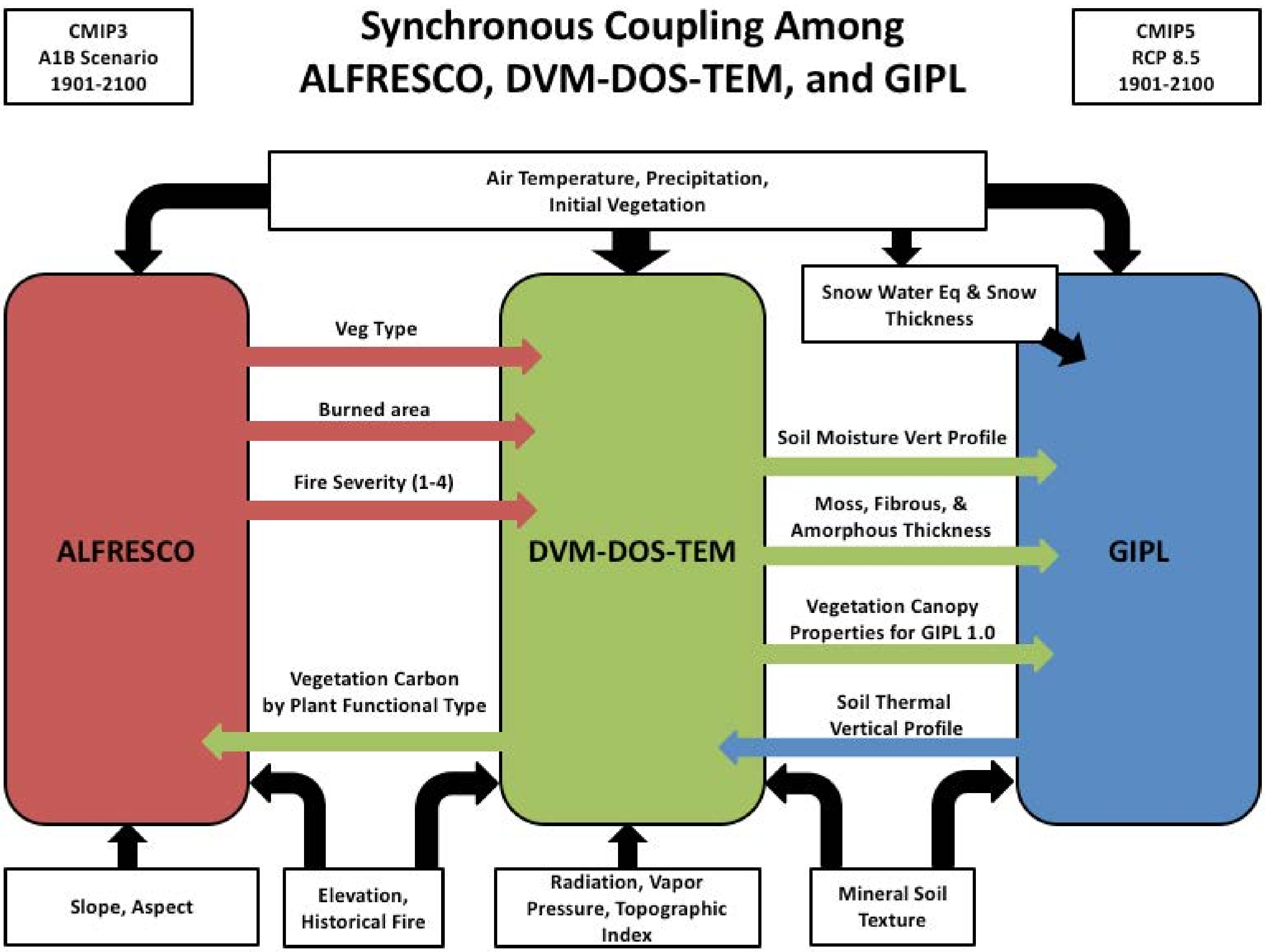


Figure 2-2. Modeling framework for the synchronous coupling among ALFRESCO, DVM-DOS-TEM and GIPL in the Integrated Ecosystem Model for Alaska and Northwest Canada.

sets for Alaska and adjacent areas of Canada, and (3) phase in additional capabilities not originally in ALFRESCO, DVM-DOS-TEM, or GIPL that are necessary to address effects of climate change on landscape structure and function. There are two different methods used to couple the models in the IEM, linear and cyclical (Figure 2-3). The first method, referred to as linear or asynchronous coupling, allows for the exchange of information between models to occur in series. For example, data generated by the first model in the series is used as input for a second model, and output from the second model is subsequently used as input for the next model. The second method, referred to as cyclical or synchronous coupling, allows data outputs to be exchanged among all models, which produce outputs at different time scales and incorporates the outputs for the next time step. The IEM output generated by linear coupling is identified as Generation 1, and the IEM output generated by cyclical coupling is identified as Generation 2. The cyclical coupling of the models is both a technical activity that is necessary so that the models can exchange data while they are running in parallel for the same climate scenario, and a scientific activity to evaluate that the temporal and spatial dynamics of the component models are appropriately aligned. The consideration of Alaska and Northwest Canada allowed us to deal with landscape issues that do not necessarily stop at the Alaska-Canada border and give the IEM the capability to support assessments of trans-boundary resource responses to climate change. With respect to current capabilities, the component models have substantial expertise in addressing fire disturbance dynamics, vegetation dynamics, and permafrost dynamics in interior Alaska, particularly with respect to upland ecosystems. Most model development work focused on better representing dynamics in lowland ecosystems. This included the development of a modeling capability to represent landscape-level thermokarst changes, which are important to incorporate into the IEM because subsidence associated with the melting of previously frozen water in ice-rich permafrost can result in substantial changes in vegetation and habitat (e.g., turning a forested permafrost plateau into a collapse scar bog). The group also worked on modeling wetland dynamics, which are important to represent because much of Alaska and Northwest Canada is covered by wetland complexes, and changes in wetland structure and function has the potential to affect numerous animal species that use wetlands (e.g., waterfowl). The development of these capabilities will provide an ability to assess the effects of climate change on animal habitat in the next phase of the IEM.

This document reports progress for the full extent of this phase of the IEM project from 1 September 2011 through 31 August 2016. There was an earlier 1-year proof of concept phase of the IEM project, which we will refer to as the previous phase of the IEM in this report. The IEM project has also been renewed for another five years starting in September, 2016, which we will refer to as the next phase of the IEM project in this report. This report is structured as follows: (1) Proposed Activities, Progress, and Next Steps, (2) Products (Data, Publications, Presentations at Scientific Conferences), (3) Outreach Activities and Presentations, (4) References, and (5) Participants. The sections on Proposed Activities, Progress, and Next Steps are reported as follows: (1) Input Data Set Development and Delivery, (2) Model Coupling, (3) Fire and Vegetation Dynamics, (4) Ecosystem Carbon Dynamics and Energy Balance, (5) Permafrost Dynamics: Region-wide Modeling Research, (6) Permafrost Dynamics: Infrastructure Modeling Research in Northern Alaska, (7) Thermokarst Modeling, (8) Wetland Dynamics: Field-based Research, and (9) Wetland Dynamics: Modeling Research.

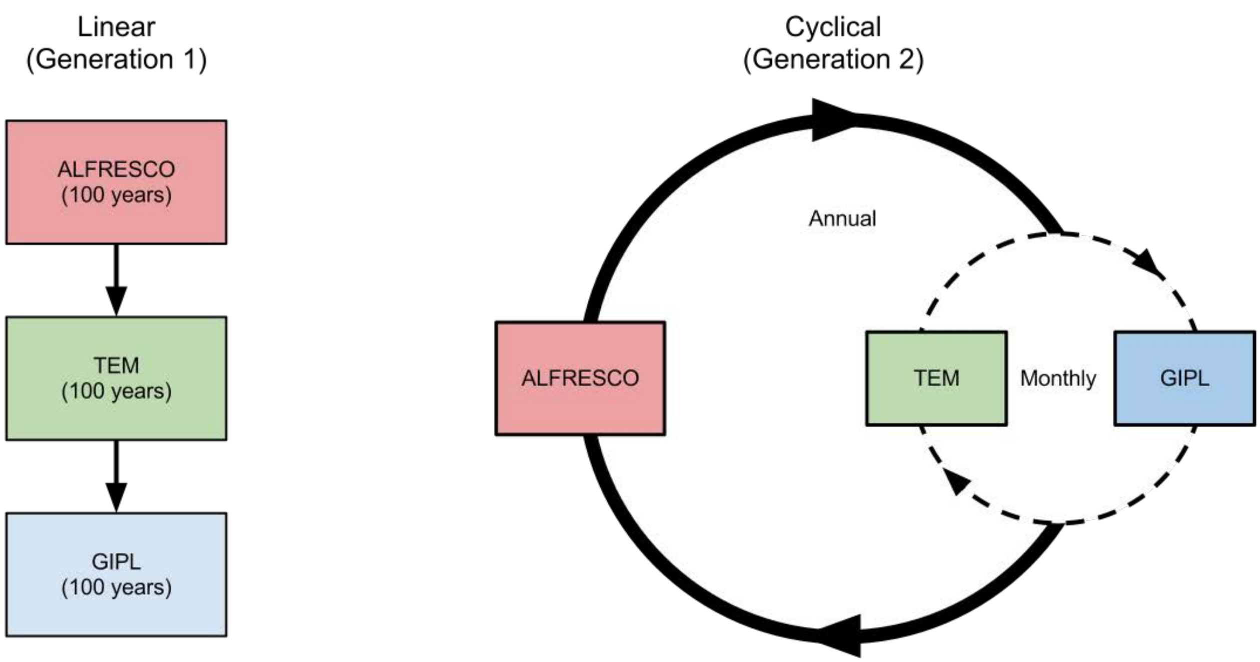
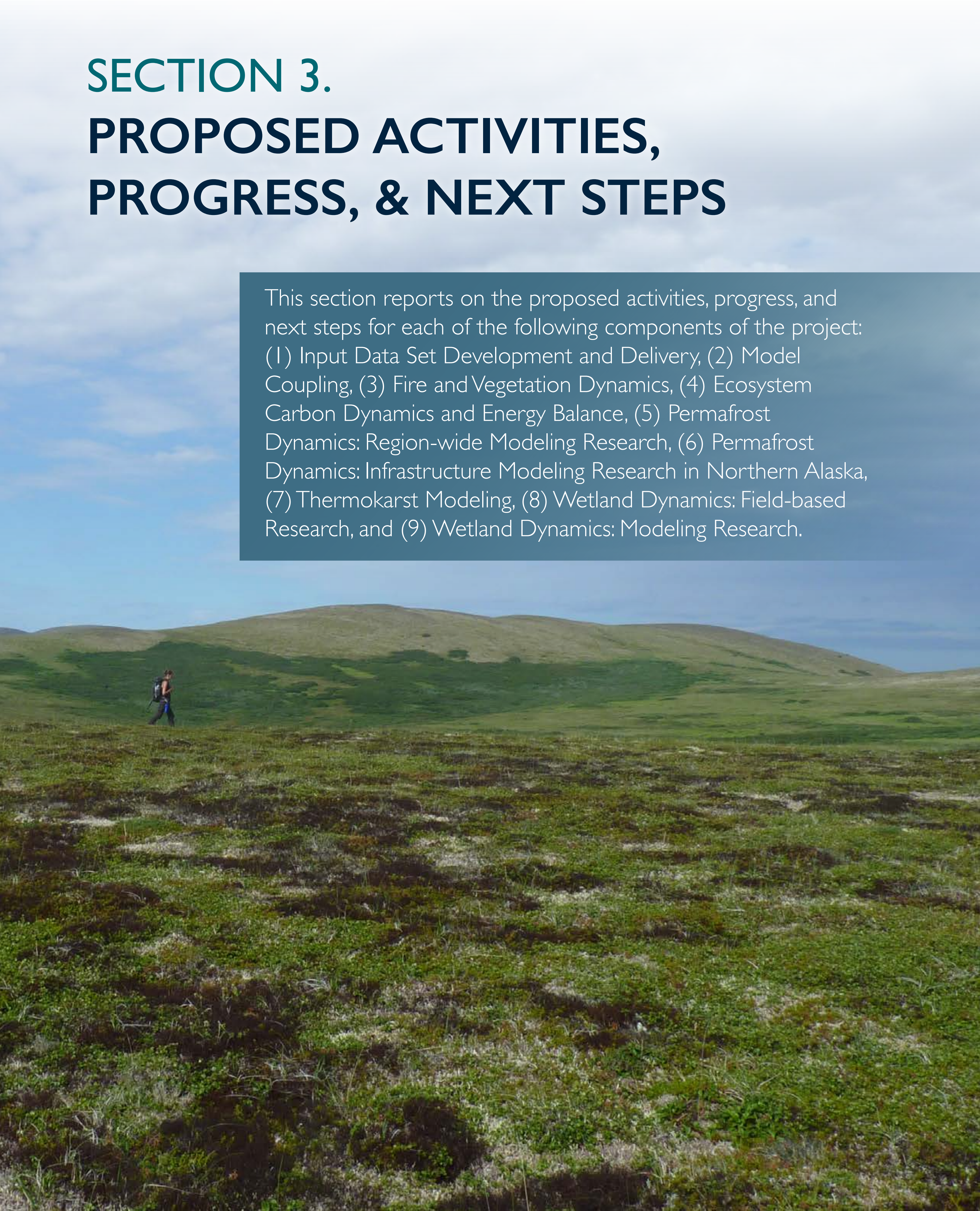


Figure 2-3. Methods for Linking the IEM Model. Diagram showing the linear (left) and cyclical (right) coupling methods used to link the three models—ALFRESCO, TEM, and GIPL—that comprise the IEM.

SECTION 3.
PROPOSED ACTIVITIES, PROGRESS, & NEXT STEPS

This section reports on the proposed activities, progress, and next steps for each of the following components of the project: (1) Input Data Set Development and Delivery, (2) Model Coupling, (3) Fire and Vegetation Dynamics, (4) Ecosystem Carbon Dynamics and Energy Balance, (5) Permafrost Dynamics: Region-wide Modeling Research, (6) Permafrost Dynamics: Infrastructure Modeling Research in Northern Alaska, (7) Thermokarst Modeling, (8) Wetland Dynamics: Field-based Research, and (9) Wetland Dynamics: Modeling Research.



3.1. INPUT DATA SET DEVELOPMENT & DELIVERY

3.1.1. PROPOSED ACTIVITIES

The IEM project included several proposed data set development activities and expected deliverables. We proposed to develop downscaled (1x1x1 km) data sets of climate drivers across Alaska and Western Canada, using both historical and projected data sources, to support modeling trans-boundary resource responses to climate change. We also proposed to develop additional data streams to support specific focus areas including tundra fire, treeline and tundra succession dynamics, and thermokarst and wetland dynamics. In year 3 of the project, after ongoing discussions with Alaska Climate Science Center investigators and LCC collaborators, we proposed additional work to include specific climate summaries as well as change datasets to better explain and visualize the effects and impacts of climate change projections. The key data products from this research are available for download at the following URL: http://ckan.snap.uaf.edu/dataset?tags=IEM.

3.1.2. PROGRESS

Extensive progress was made on the proposed input data development and delivery. In deciding the spatial extent of the study, we completed a comprehensive review of all historical and projected data available to support the proposed modeling efforts. This included a survey into the strengths and weaknesses of historically observed vs historical reanalysis data. Due to the large spatial extent and remote characteristics of the IEM region, there are limited high resolution climate observations available. Climatic Research Unit (CRU) high resolution climate data (Harris et al. 2014) was chosen due to long record, a relatively rapid update cycle, availability of all required variables, and because it is based on actual observed climate as opposed to modeled outputs. Our analysis indicates that in the last 60 years, Alaska has seen a large increase in mean annual air temperature (1.7 °C), with the greatest warming occurring over winter and spring.

Monthly projected data were obtained from the Coupled Model Intercomparison Project (CMIP; Meehl et al 2007, Taylor et al. 2012) which supports the Intergovernmental Panel on Climate Change (IPCC 2013, 2014) reporting efforts. The IEM used climate inputs from either CMIP3 (IPCC Assessment Report 4) and CMIP5 (IPCC Assessment Report 5) models. To select the best subset of models to use in the IEM, we completed two separate model selection procedures across the full set of CMIP3 and CMIP5 models (~45 models). We selected the top 5 models from each CMIP model group that best replicated broad scale historical patterns of temperature, precipitation, and sea level pressure across Alaska and Canada, following methods from Walsh et al. (2008).

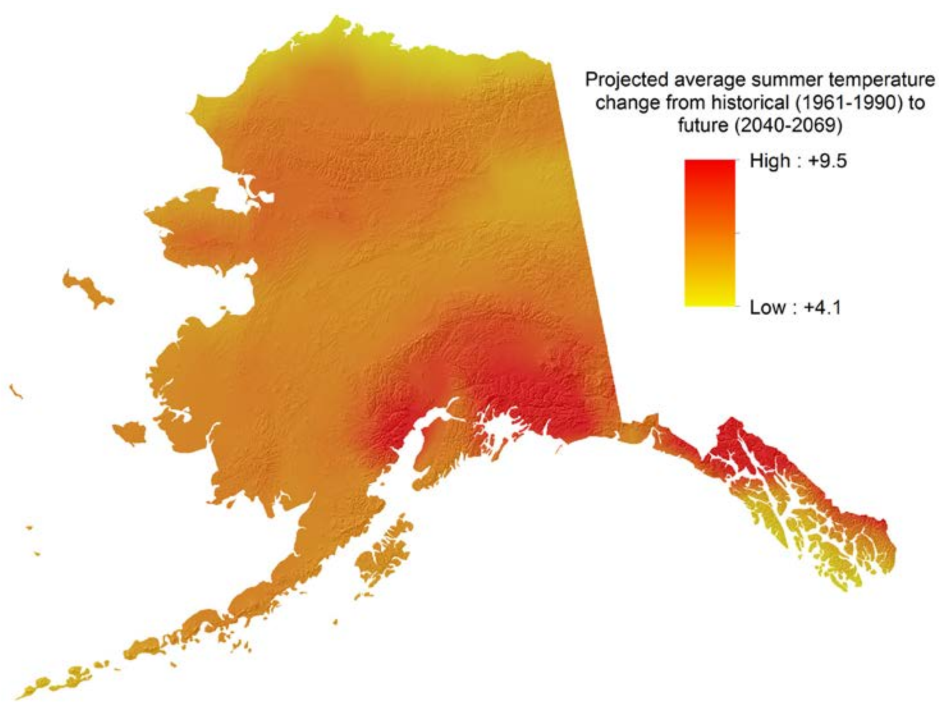


Figure 3.1.2-1. Change in summer average temperature from 1961-1990 (PRISM) to 2040-2069 (NCAR CCSM4, RCP 8.5).

Due to the highly variable nature of wildfire from year to year, our next goal was to bracket the projected variability in ALFRESCO runs by determining which climate model inputs resulted in the most and least cumulative area burned. This approach allowed us to explore the full range of likely future projections of fire. After calibrating ALFRESCO to historically observed fire metrics, we ran ALFRESCO using all 10 climate model inputs to determine which models' climate data inputs resulted in the most and least cumulative are burned from now until 2100. This allowed us to bracket the variability and limit the IEM assessment to 2 models for each set of CMIP runs. The resulting CMIP3 models include CCCMA-CGCM3.1(T47) and MPI-ECHAM5/MPI-OM, and we used the conservative A1B scenario. CMIP5 models for RCP 8.5 include NCAR-CCSM4 and MRI-CGCM3. RCP selection for AR5 runs is still being discussed.

The full set of 10 models, 6 scenarios, and 4 variables were downscaled using the delta method. The delta method calculates climate anomalies between historical and future climate at the GCM scale, interpolates those to the observed baseline climate resolution, and then combines them with the observed climate dataset. This approach removes model specific bias, by using an observed climatology as the baseline climate. CRU data (10 minute resolution) was used as baseline climate for vapor pressure (calculated from relative humidity) and radiation (derived from cloudiness). PRISM data (2km) were used as baseline climate for temperature and precipitation. Full details of the downscaling methods are available in the metadata. We also developed an initial set of specific climate summaries and change GIS datasets showing how CMIP3 and CMIP5 models compare through time and to historical data (Figure 3.1.2-1). These products are currently being developed into more user friendly interactive plots.

In addition to the above time series climatic variables, we also developed a land cover classification to allow the models to better distinguish forest cover types from tundra, wetland tundra from upland tundra types, and heath from other upland shrub types, as these dynamics are specific focuses of the IEM. We derived various topographic variables including elevation, slope complexity and aspect.

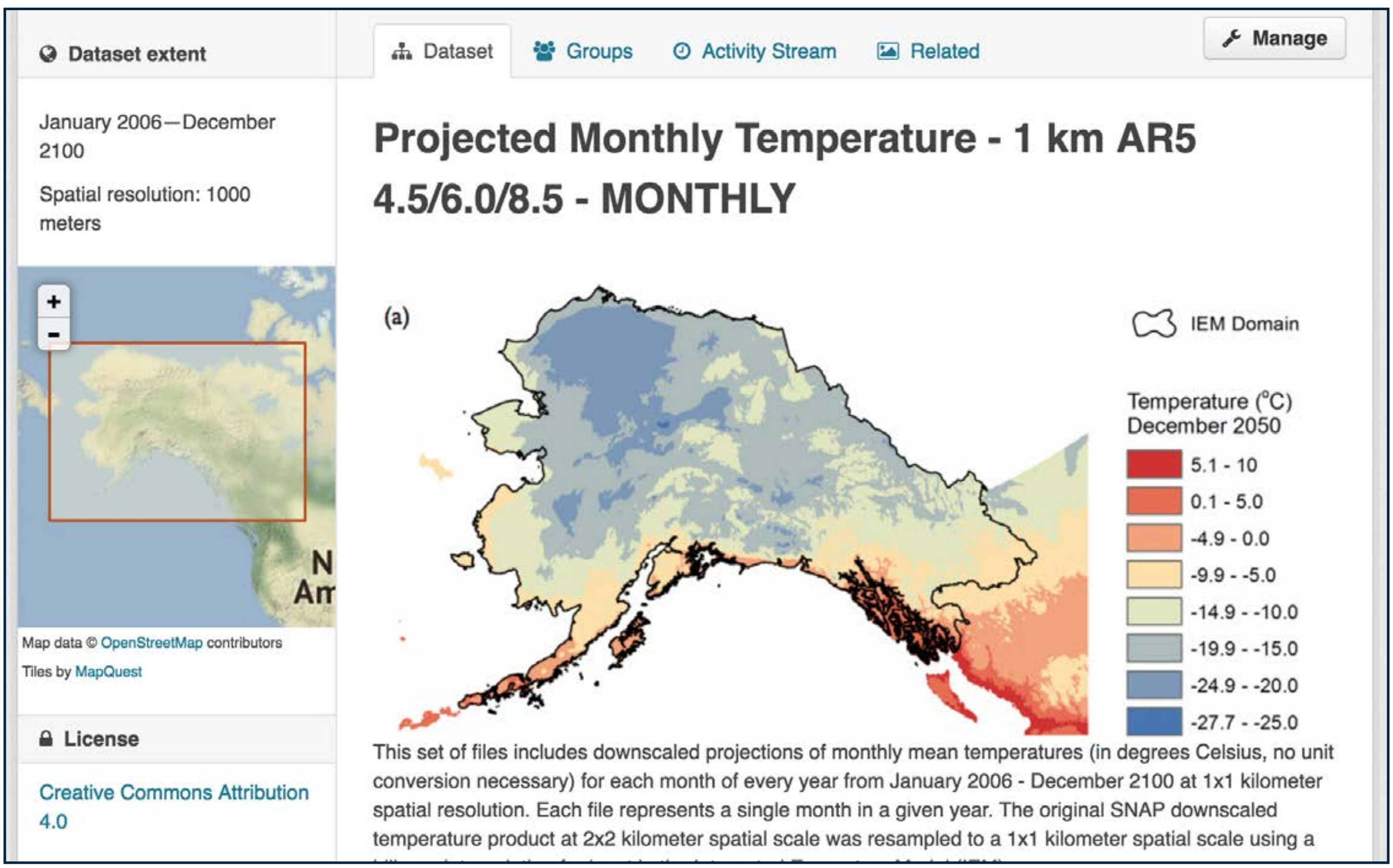


Figure 3.1.2-2. Screenshot of the SNAP data portal, (http://ckan.snap.uaf.edu/dataset?tags=IEM).

We completed a research data management plan that adheres to the Department of Interior Climate Science Center Policy. This document outlines how the IEM team will facilitate full and open access to data products produced by this study. Due to the volume and complexity of this project, we developed a more user friendly data publishing platform, generally referred to as the SNAP data portal (Figure 3.1.2-2). This platform allows ingestion of ISO metadata records, but also allows supplementary information and files to be attached to each record, such as programming code, references, or links to project pages. It is an open source solution, which enables more flexibility in the future when collaborating with other data portals. Please refer to the section below on data products for a full listing of available model input and output data. You can obtain all IEM related data from the SNAP data portal (http://ckan.snap.uaf.edu/dataset?tags=IEM).

3.1.3. NEXT STEPS

Going forward, we will continue to support the publishing of all model outputs from the current Generation 1 runs and the to-be-conducted Generation 2 runs of the IEM. We will also support the development of retrospective data sets pertaining to biogeophysical (e.g., soil temperatures, active layer depths) and vegetation (e.g., productivity) variables for model evaluation. As various impact models are being developed, we will support the delivery of supplemental data summaries as required for those model runs. It is likely that new or updated data sets will be needed for driving the additional IEM capabilities such as thermokarst dynamics, wetland dynamics, and herbivory and vegetation dynamics. In addition, if IPCC Assessment Report 6 is completed with new CMIP model output, we will consider using those outputs depending on the status of the IEM at that point in time. We will remain engaged with other national and international data portals to promote federation of our data holdings to other systems to improve discoverability of IEM outputs.

3.2. MODEL COUPLING

3.2.1. PROPOSED ACTIVITIES

A major goal of this project was to develop a method to integrate multiple research models in a way that allowed for more complex systems dynamics and dynamic data usage. To develop a solution for an integrated modeling environment, it was first important to understand how the individual component models (ALFRESCO, DVM-DOS-TEM, GIPL) functioned, their input/output needs, computational requirements, and social dynamics of the groups developing these models. These models posed significant challenges to coupling, as they have different spatial awareness, time step requirements, and different quantitative representations and methodologies (e.g., mechanistic rules and stochasticity for ALFRESCO and deterministic process-based numerical solutions for DVM-DOS-TEM and GIPL). In addition to the structural differences, these models are maintained by different research groups, and the models themselves have demanding processing and data storage requirements.

A computational structure was designed to address the challenges of the independent modeling groups, the models themselves, and the requirements for data sharing and computational needs. Individual modeling groups continue to control the source code for the independent models. Within each model, changes have been outlined for sections that will require interaction with coupled aspects of each (related variables, data access, time step control functions, etc.). A common "coupling" environment was designed to handle the time step synchronization (stepping forward by months or years as required) and data sharing between models using common data arrays accessed by each model via standardized function calls (Figure 3.2.1-1). Individual models have been compartmentalized to support modular use of "shared libraries", so that these libraries could be included for use by the integrated model, or for use by independent models. Common data are passed through the coupler to prevent extensive input/output slowdowns for temporary state data. Along with this design, substantial framework development, reduction of redundancy, and the redesign of model code was required among the component models. Modeling groups were also required to redesign portions of the model to support greater integration capabilities, standardized formats, common source code maintenance, and support for the coupled environment. Additionally, it was necessary for all component modeling groups to support a method within their model for time step synchronization so that the models would be able to trade current information from the spatial domain at monthly or yearly intervals as appropriate.

3.2.2. PROGRESS

The coupler executable was developed and tested, and continues to undergo changes as progress is made to component models. Currently, it supports the modeling infrastructure (time step synchronization, data sharing, storage, etc.), with individual modeling groups handling specific changes as they advance the representation of science advancements in their models. Within shared memory space, there exists a "truth repository" of data structures that can be accessed/modified by the component models when needed without impacting the variables within each model. The executable has access to runtime functions within the three component models, which allows each model to be stepped forward in a controlled fashion. This allows for dynamic data passing at standard intervals. This code has been made available in a public repository for shared access and visibility. This code has been used to complete sample "small domain" runs as a proof of concept, consisting of a handful of cells run through the time series. Although these proof of concept runs are indicative of functionality of the integrated modeling system, the integrated modeling framework still needs to be further exercised and evaluated to understand the implications for the application of the modeling framework to the full IEM domain.
A large amount of effort has been dedicated to individual work in the component models. Each of the three models now support the ability to build and distribute independent libraries of that model. These models can be linked into a single executable (for independent work) or into a common "coupled" environment for integrated work, which provides substantial flexibility for model application. Support has also been added to some of the models for specific data pathways (biomass, fire size, fire location, etc.). Source code is now hosted for all models in a common location, allowing

contributors to view and access the code of partnering groups. The component models are now built and deployed as RPM (RPM Package Manager) packages. Automated build processes were set up to standardize deployment and consistency, allowing simplified installation of the models. A large refactoring of input/output methods has been completed in DVM-DOS-TEM, which allows more transparent access to data and supports climate research standards and improved access to existing geospatial tools.

To support the computational and storage requirements of the IEM, a computing cluster was purchased, installed, and configured. This system (Atlas) is being heavily utilized for work related to the IEM project and has allowed great advances to be made. The system is a 15 node cluster (allowing 480 total processes), supporting large memory, large storage support, and high networks speeds to support the modeling framework. This resource has allowed for greater simulation capabilities, and more refined calibration of the models for greater accuracy and prediction support.

3.2.3. NEXT STEPS

While significant progress has been made on the component models and the coupling environment, there is still more that remains to be done. As the highest priority, it is important to fully implement parallel processing for DVM-DOS-TEM. This model has a large requirement for computational time, and it will be extremely important to address this hurdle for the completion of full domain simulations. Work is underway to address this issue, and additional work is being applied to optimize the model code.

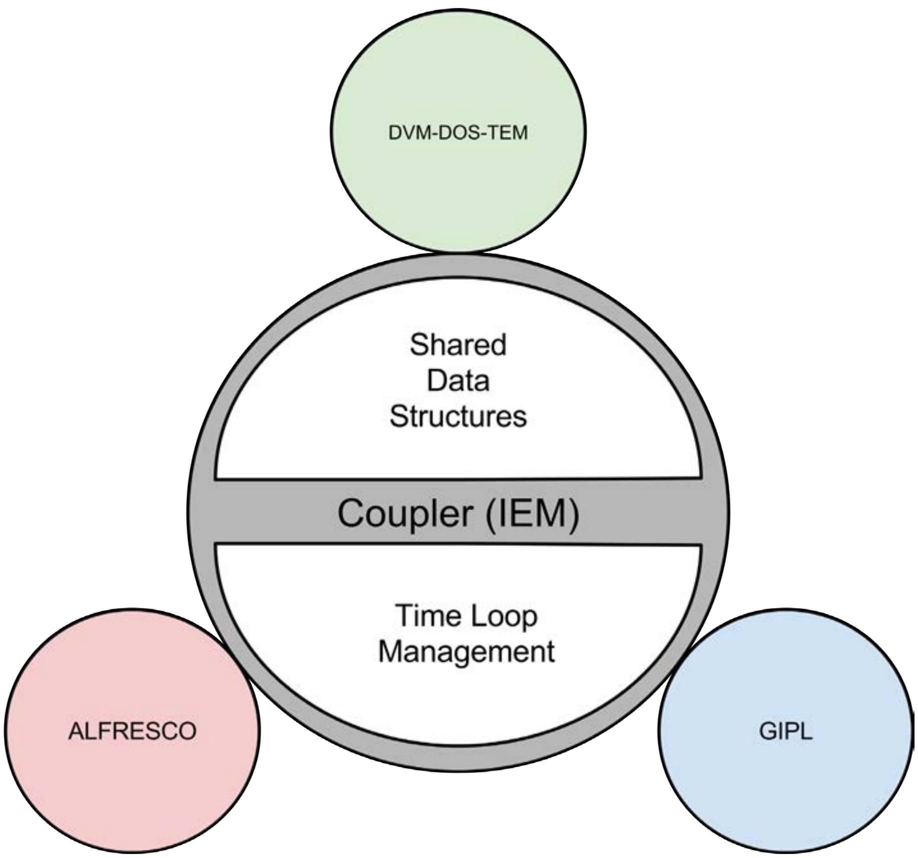


Figure 3.2.1-1. The Loose Coupling approach to synchronous coupling to allow each component model (ALFRESCO, DVM-DOS-TEM, and GIPL) in the Integrated Ecosystem Model for Alaska and Northwest Canada to be maintained independently.

Once parallel development is satisfactorily completed, work will move forward on a test case for scalability. There is still uncertainty associated with this, as previous full scale runs of the model have been on the order of multiple weeks and/or months. A small subset area will be used to assess the total resources required to complete domain-wide simulations. After that is completed, full domain simulations will begin. While full domain simulations pose a significant computational challenge, it is an expected requirement of the integrated modeling framework. Future optimization of the parallel computation versions combined with increased hardware capacity going are expected to meet this challenge.

3.3. FIRE & VEGETATION DYNAMICS

3.3.1. PROPOSED ACTIVITIES

The proposed fire and vegetation dynamics activities this phase of the IEM project focused on development of new functionality to better simulate tundra fire regimes and vegetation succession with the aim to forecast landscape changes in tundra regions of Alaska and northwest Canada. These improvements were implemented in ALFRESCO and were focused on the role of climate and wildland fire disturbance on the conversion of tundra to shrubland and forest.

3.3.2. PROGRESS

New fire and vegetation dynamics functionality was added to ALFRESCO. A single generic tundra vegetation class was separated into three classes of varying flammability: graminoid tundra, shrub tundra and wetland tundra. We also implemented tree migration and tundra transition routines in ALFRESCO (Figure 3.3.2-1, Breen et al. in preparation), and added an optional routine to evaluate the influence of mycorrhizal fungi in the soil on treeline expansion (Hewitt et al. 2015). The calibration regime in ALFRESCO was also altered to separately optimize the model for the tundra and boreal regions of the study area as fire dynamics differ between these regions. These results and information on fire severity were then passed to DOS-TEM to model active layer thickness and carbon storage after fire in Interior Alaska (Genet et al. 2013, 2016) and the consequences of changes in vegetation and snow cover for biophysical climate feedbacks in Alaska and northwest Canada (Euskirchen et al. 2016).

In addition, through leveraged projects including a Department of Defense Strategic Environmental Research and Development Program (SERDP) funded project titled, "Identifying Indicators of State Change and Forecasting Future Vulnerability of Alaskan Boreal Ecosystems" and a USGS funded project titled, "Baseline and Projected Future Carbon Storage and Greenhouse Gas Fluxes in Ecosystems in Alaska," we created: (1) relative flammability and relative vegetation change maps for the study region (Rupp et al. 2016), (2) projected fire and land cover change for the Landscape Conservation Cooperatives in Alaska (Rupp et al. 2016), and (3) a fire suppression routine to investigate how increasing fire suppression through altering fire management planning options (FMPO) may influence the extent and frequency of wildfire activity in Interior Alaska (Breen et al. 2016, Figure 3.3.2-2).

Simulations of the dynamics of wildfire and vegetation succession for historical (1950-2009) and future (2010-2100) time periods across the IEM domain driven by the two bounding CMIP3 models and A1B scenario were conducted. Fire frequency and area burned have increased in recent years across Alaska and northwest Canada, and the trend is projected to continue for the rest of the century for both climate models. The boreal region is projected to see the highest increase in fire activities, and likewise late successional vegetation in the region, such as spruce forest, was projected to decline, whereas early to mid-successional vegetation, such as deciduous forest, was projected to increase. In tundra regions, shrub tundra is generally projected to increase and graminoid tundra to decrease.

3.3.3. NEXT STEPS

In the next phase of the IEM project, we will drive ALFRESCO with the new generation of Global Circulation Models (GCMs) and projections (CMIP5; IPCC 2013) to generate next generation fully coupled IEM results. This requires calibration and other technical tasks to upgrade from the previous generation of GCMs. We will also add new IEM functionality via an herbivory and vegetation dynamics module in ALFRESCO, focused on caribou and moose. ALFRESCO has been used to study herbivory and vegetation dynamics in the past, although not recently. There is a need to consider how these processes should be incorporated into the IEM as tundra herbivory, particularly by reindeer and caribou, has been shown to counteract climatically induced encroachment of trees and shrubs in tundra; the impact can be strong enough to cause transitions between vegetation states in these ecosystems.

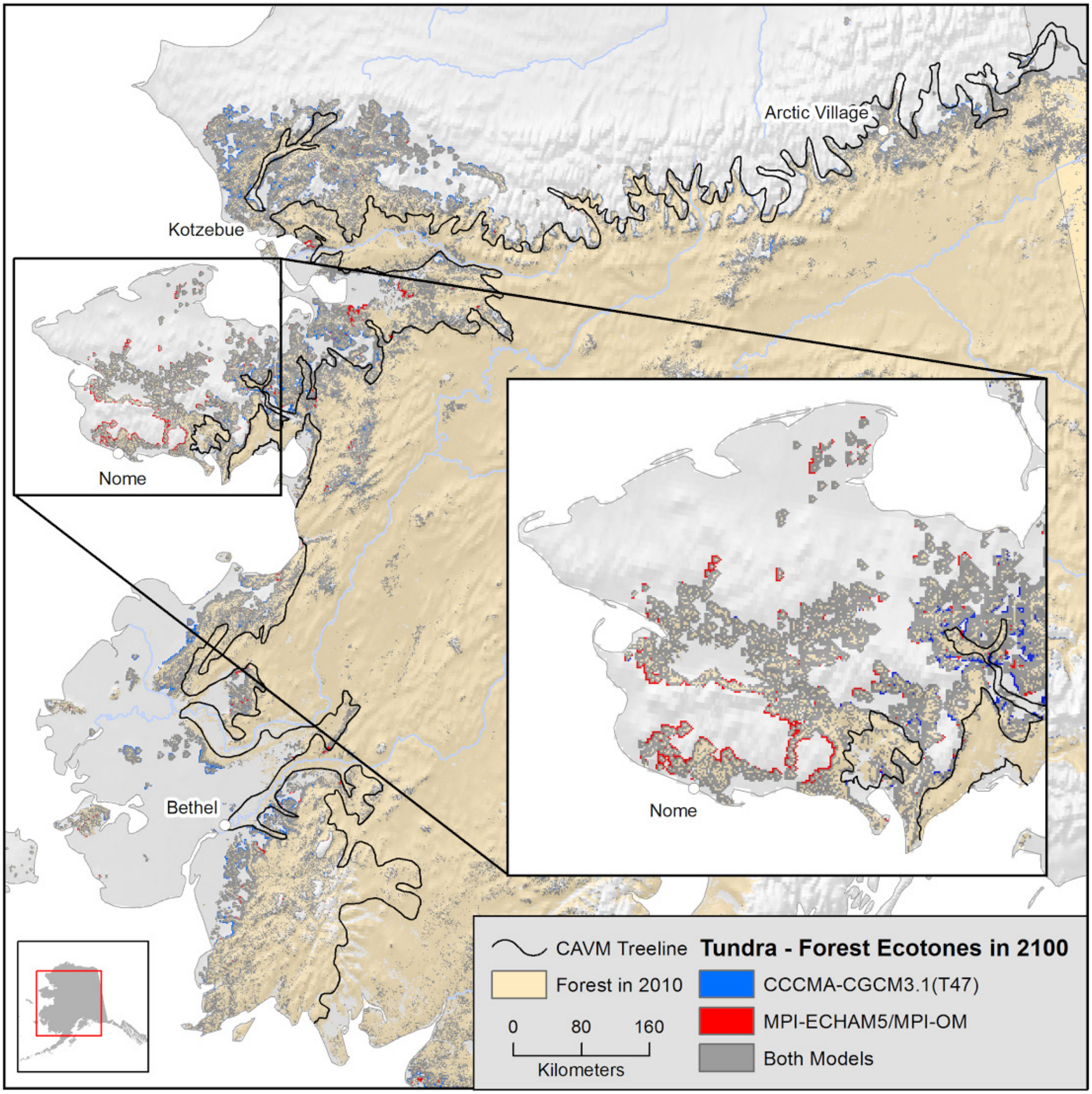


Figure 3.3.2-1. ALFRESCO model outputs showing projected changes for treeline in the tundra regions of Alaska. The figure shows tundra pixels that converted to forest by 2100 in blue. The Circumpolar Arctic Vegetation Mapped treeline is also shown for comparison (CAVM Team 2003).

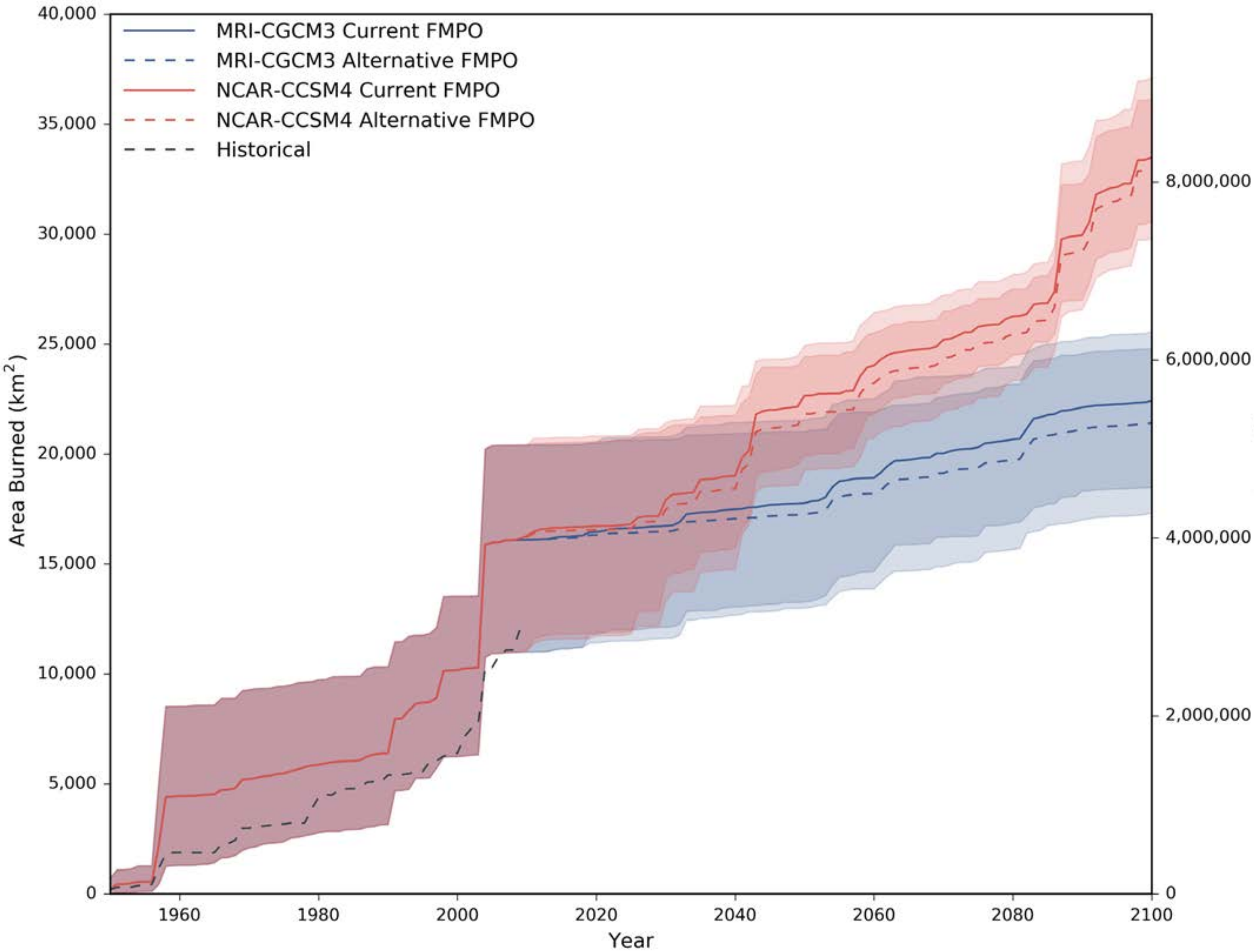


Figure 3.3.2-2. Cumulative area burned during the historical (1950-2009) and projected (2010-2100) periods for the Upper Tanana Hydrological Basin in Interior Alaska. Model results are presented for fire management scenarios driven by the NCAR-CCSM4 and MRI-CGCM3 AR5 GCMs for the RCP 8.5 scenario. Data presented are means and shading indicates results from 200 model replicates. Results suggest changing FMPO (fire management planning options) from the status quo (mostly Limited protection) to Full protection led to an increase in the number of fires, but a decrease in the total area burned through 2100 (Breen 2016).

3.4. ECOSYSTEM CARBON DYNAMICS & ENERGY BALANCE

3.4.1. PROPOSED ACTIVITIES

We proposed to evaluate the impact of wildfire and vegetation dynamics on biogeochemical and biophysical feedbacks across Alaska and Northwestern Canada in response to changing climate. The biogeochemical feedback was estimated by quantifying ecosystem carbon balance, i.e., the dynamics of the main ecosystem carbon fluxes and how they impacts vegetation and soil C stocks. Changes in vegetation carbon stocks were estimated as the net result of the carbon gain from vegetation productivity (net primary productivity, NPP) and the carbon losses from litterfall and fire emissions. Changes in soil carbon stocks were estimated as the net result of the carbon gained from vegetation litterfall and the carbon loss from heterotrophic respiration, fire emissions and methane emissions. The biogeophysical feedback was estimated by quantifying the seasonal dynamics of atmospheric heating for each vegetation type. Atmospheric heating, which represents the changes in radiation that are absorbed by the atmosphere, was estimated by multiplying incoming solar irradiance by the proportion of incoming irradiance that is absorbed by the land surface times the proportion that is transferred to the atmosphere (Chapin et al. 2005, Euskirchen et al. 2007, Euskirchen et al. 2016).

3.4.2. PROGRESS

Carbon and atmospheric heating assessments were based on simulations from DOS-TEM and ALFRESCO. DOS-TEM simulated snow and active layer dynamics, carbon and nitrogen pools, and fluxes between soil, vegetation and the atmosphere. The model framework was developed to better represent the effect of wildfire on both tundra (Breen et al. in prep.) and boreal (Genet et al. 2013) ecosystems. Biogeophysical and biogeochemical processes were assessed at different spatial resolution. Carbon dynamics were simulated by DOS-TEM at a 1-km resolution, with a dynamic climate and fire regime, and static vegetation composition (Figure 3.4.2-1, Genet et al. 2016; He et al. 2016). Changes in atmospheric heating were estimated for each Landscape Conservation Cooperative region in the IEM domain along with dynamic climate, fire regime and vegetation composition. Atmospheric heating was estimated using snow cover from DOS-TEM, and fire and vegetation dynamics from ALFRESCO (Figure 3.4.2-2, Euskirchen et al. 2016).

With mutual support from the USGS Alaska Land Carbon project, projections of carbon dynamics were produced for 4 additional climate scenarios (CCCMA-CGCM3.1(T47) and MPI-ECHAM5/MPI-OM for emission scenarios B1 and A2). DOS-TEM was coupled with the Methane Dynamic Module (MDM)of TEM (Zhuang et al. 2004) to assess methane production from wetlands using a new wetland map based on National Wetland Inventory data (He et al. 2016). Additionally, an attribution analysis was conducted to evaluate the relative effect of atmospheric CO_2 fertilization, change in climate, and change in fire regime on the ecosystem carbon balance (Genet et al. in preparation). The model outputs have been evaluated by comparing historical simulation of vegetation carbon stocks with vegetation biomass estimates provided by the Cooperative Alaska Forest Inventory (Malone et al. 2009) and the Long Term Ecological Research Sites in Bonanza Creek (http://www.lter.uaf.edu/) and Toolik Lake (http://toolik.alaska.edu/). Soil carbon stocks were validated by comparing historical simulations with soil carbon stocks estimated from soil pedons and provided by the National Soil Carbon Network (http://iscn.fluxdata.org/). The results of the model validation are available in the USGS Land Carbon Assessment Report for Alaska (Zhou et al. 2016, Chapter 6).

3.4.3. NEXT STEPS

In the next phase of the IEM, DVM-DOS-TEM will be applied to simulate successional changes in land cover transitions associated with fire and thermokarst disturbances. This version of TEM requires that new sets of parameterizations be developed for the main vegetation communities present in Alaska and Northwestern Canada (i.e. shrub, tussock, wet sedge and heath tundra, black spruce, white spruce and deciduous forest, collapse scar bog and fen, upland and lowland maritime forest, maritime fen and alder shrubland). Finally, recent data collected on the effect of fire in tundra and boreal ecosystems will be used in DVM-DOS-TEM to improve its capacity to represent the spatio-temporal patterns of biogeochemical and biogeophysical processes. Currently, the predictive model of fire severity in TEM is based on field observations collected in boreal black spruce forest and a single tussock tundra fire (the 2007 Anaktuvuk River fire). Additional data collected on the effect of fire in other types of ecosystem will be analyzed and integrated into the model. The effect of this integration will be evaluated by comparing the spatial and temporal patterns of the effects of fire between one-way and two-way couplings of the model with ALFRESCO.

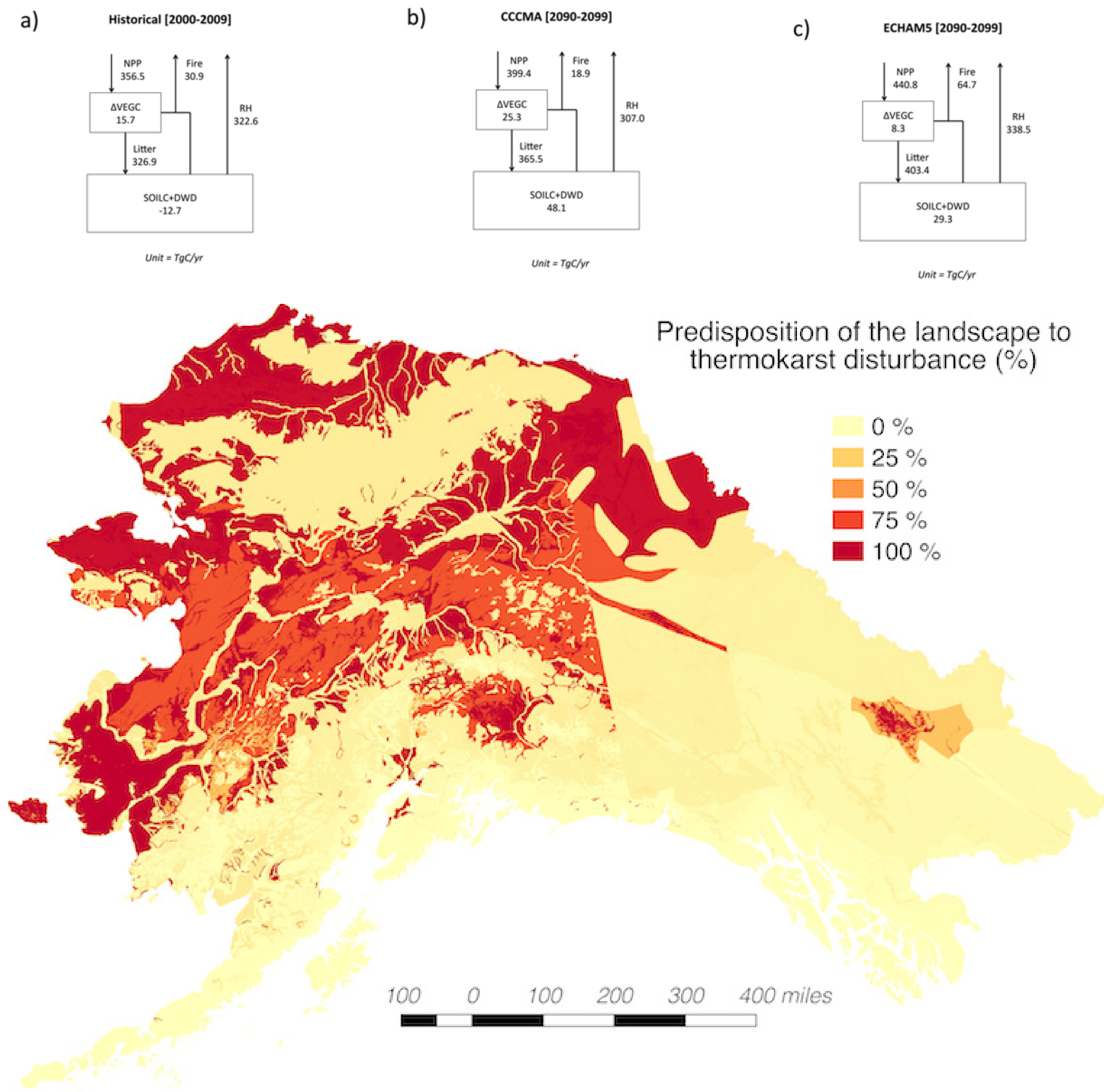


Figure 3.4.2-1. Carbon balance summary for the IEM spatial extent for a) the end of the historical period (2000-2009), b) the end of the projected period (2090-2099) for the CCCMA, and c) the ECHAM5 scenarios, and d) Combined soil and vegetation carbon stocks averaged between CCCMA and ECHAM5 scenarios by 2099. Abbreviations: NPP= vegetation net primary productivity, Fire= fire emission from the vegetation and the soil, RH= heterotrophic respiration, Litter= litterfall, □VEGC= change in vegetation carbon stocks, □SOILC+DWD= changes in carbon stocks in the soil (organic and mineral layers) and dead woody debris. The model simulations indicate that the IEM region was a small sink for carbon during the historical time period and becomes a much stronger sink for carbon in the future.

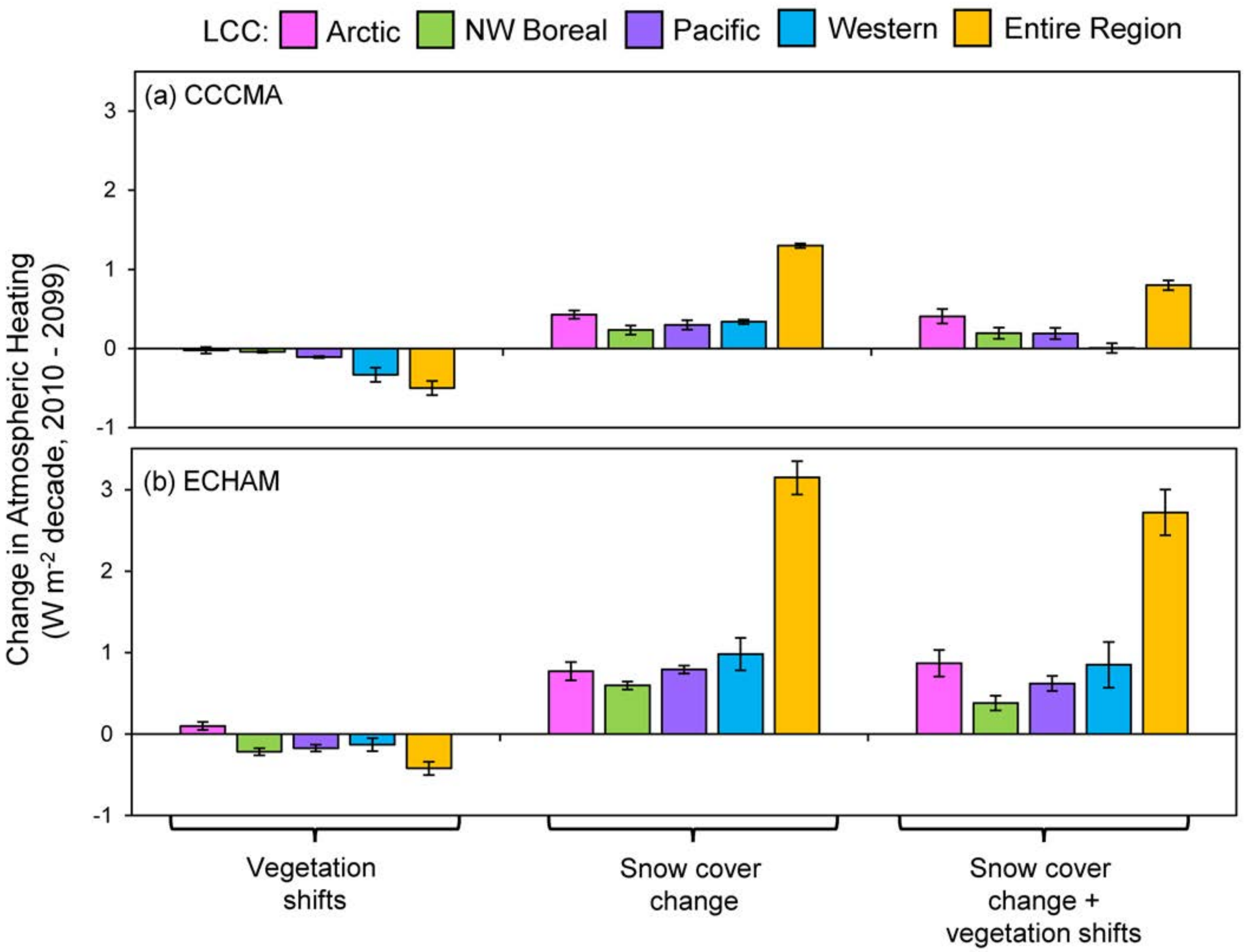


Figure 3.4.2-2. Changes in atmospheric heating over the IEM domain (2010 – 2099, W m-2 decade-1) due to changes in vegetation cover and the snow season duration for the a) CCCMA scenario and b) ECHAM scenario. Error bars represent standard error. These results indicate that changes in snow cover duration, including both the timing of snowmelt in the spring and snow return in the fall, provided the dominant positive biogeophysical feedback to climate across all LCCs, and were greater for the ECHAM (+3.0 W m-2 decade-1 regionally) compared to the CCCMA (+1.3 W m-2 decade-1 regionally) scenario due to an increase in loss of snow cover in the ECHAM scenario. The greatest overall negative feedback to climate from changes in vegetation cover was due to fire in spruce forests in the Northwest Boreal LCC and fire in shrub tundra in the Western LCC (-0.3 W m-2 decade-1 in both of these LCCs).

3.5. PERMAFROST DYNAMICS: REGION-WIDE MODELING RESEARCH

3.5.1. PROPOSED ACTIVITIES

The GIPL model was developed specifically to assess the effect of a changing climate, vegetation succession, and vegetation migration on permafrost (Marchenko et al. 2008, Nicolsky et al. 2009, Jafarov et al. 2012). The GIPL model simulates soil temperature dynamics and the depth of seasonal freezing and thawing by solving the non-linear heat equation numerically without loss of latent heat effects in the phase transition zone. In this model, the process of soil freezing and thawing is occurring in accordance with frozen and unfrozen water content and soil thermal properties, which are specific for each soil layer and each geographical location. The time-step of GIPL model is daily. After a hundred-year spin-up, soil temperature is fully stabilized at the vast majority of points. Inclusion of a deeper soil column down to 100 m (Figure 3.5.2-1) significant improves simulations of permafrost and active layer dynamics due to the thermal inertia from a deep heat sink in the soil. Our primary objective for the regional simulations of GIPL conducted in this phase of the IEM project was to drive the model with input data sets derived from simulations of DOS-TEM over the entire IEM domain. These spatial datasets included snow depth, organic horizon thickness, soil thermal properties, and seasonal soil water variability.

3.5.2. PROGRESS

We estimated the dynamics of permafrost temperature and active layer thickness for historical (1901-2009) and future (2010-2100) time periods across the IEM domain. Simulations of future changes in permafrost indicate that, by the end of the 21st century, late-Holocene permafrost in Alaska and Northwest Canada will be actively thawing at all locations and that even some Late Pleistocene permafrost will begin to thaw at some locations. Modeling results also indicate how different types of ecosystems and fire disturbances affect the thermal state of permafrost and their stability. Although the rate of soil warming and permafrost degradation in peatland areas are slower than other areas, a considerable volume of peat in Alaska and Northwest Canada will be thawed by the end of the current century (Figure 3.5.2-2). The net effect of this thawing strongly depends on soil moisture dynamics, fire severity, presence or absence of organic matter, and surface vegetation.

3.5.3. NEXT STEPS

In the next phase of the IEM project, the individual models will be linked cyclically, which allows data to be exchanged with GIPL at monthly time steps. Our primary focus with GIPL in the next phase will be to work on the details of the cyclical linkage of GIPL with DVM-DOS-TEM.

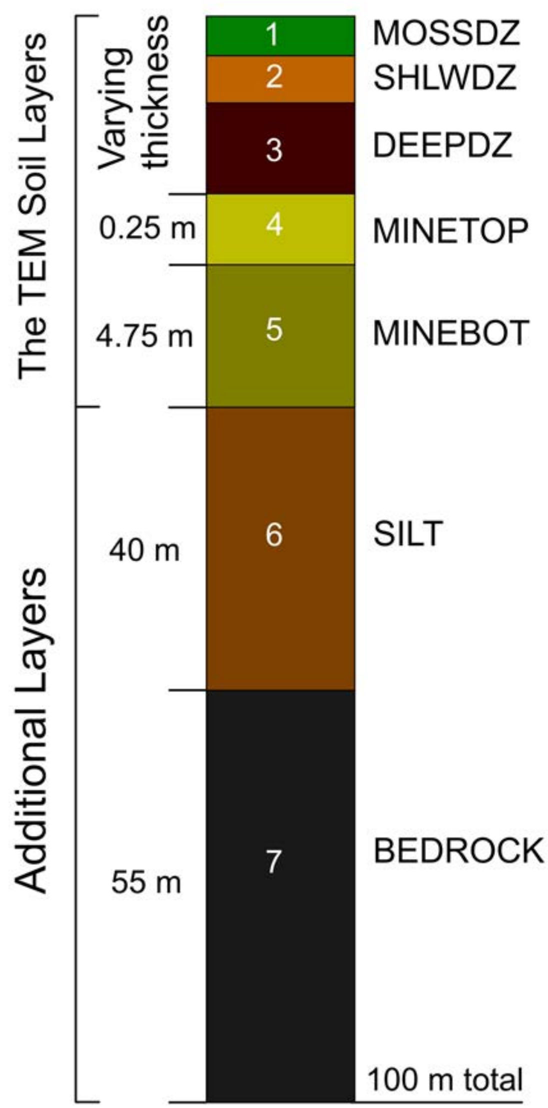


Figure 3.5.2-1. Soil column showing the horizons used for GIPL permafrost dynamics simulation. MOSSDZ - thickness of the moss layer, SHLWDZ - thickness of the fibric organic layer, DEEPDZ - thickness of the humic organic layer, MINETOP - top mineral layer is 0.25 m thick from the bottom of the organic layer, MINEBOT - bottom mineral layer is 4.75 m thick from the bottom of the top mineral layer, SILT – 40 m thick and BEDROCK – 55 m thick are additional layers. The total depth of the soil column is 100 m with no organic layers.

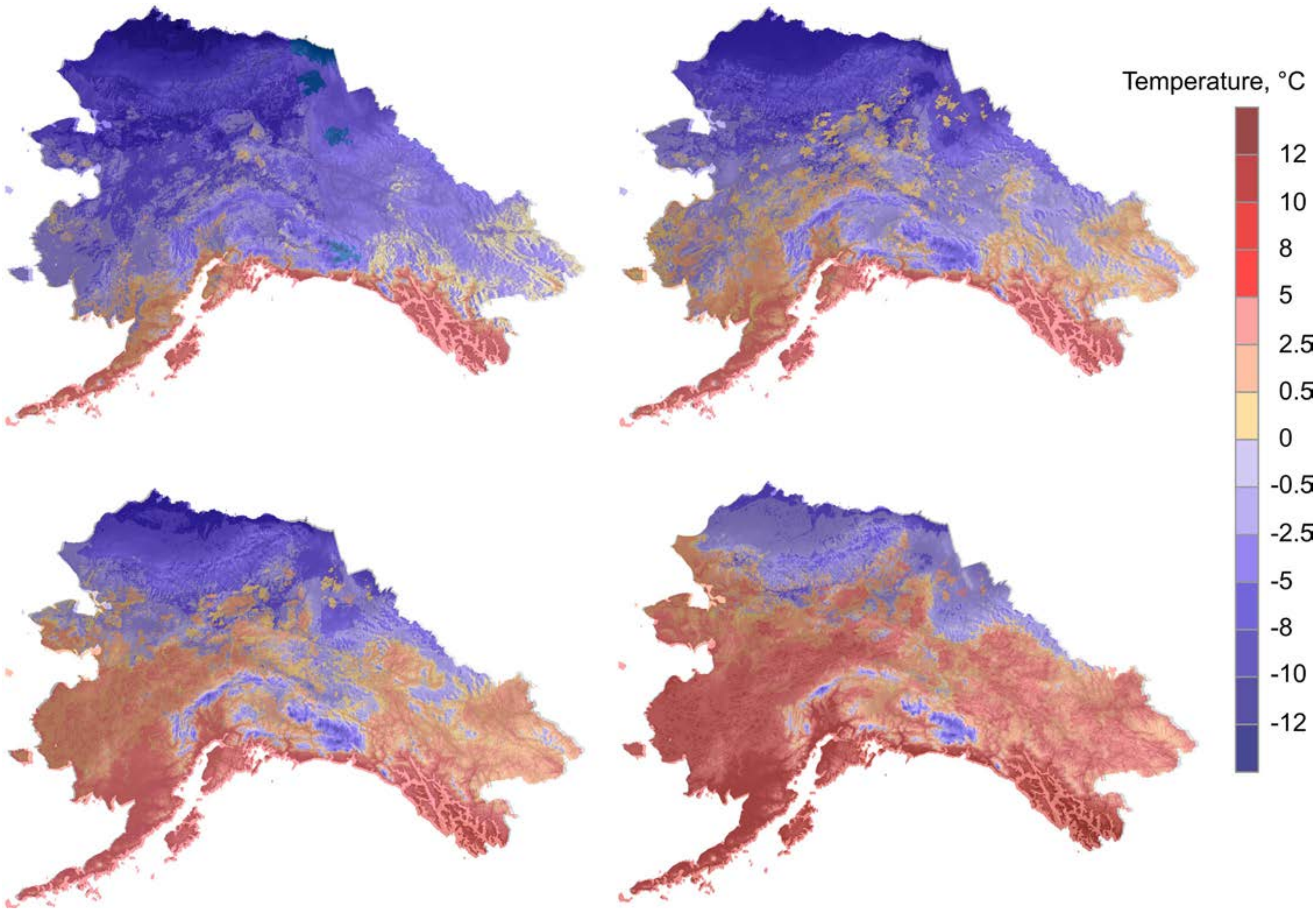


Figure 3.5.2-2. The mean annual soil temperature simulated by GIPL at 1 m depth, using historical and a future climate scenario (CCCMA-CGCM3.1 A1B) as climate forcing, and DOS-TEM output for subsurface parametrization. Results for various time snapshots are shown: 1950 (top left), 2000 (top right), 2050 (bottom left) and 2100 (bottom right).

3.6. PERMAFROST DYNAMICS: INFRASTRUCTURE MODELING RESEARCH IN NORTHERN ALASKA

3.6.1. PROPOSED ACTIVITIES

To understand how the potential changes in permafrost will affect infrastructure on local and regional scales, we modeled the ground temperature dynamics using the RCP 4.5 and 8.5 scenarios for disturbed ground conditions. In particular, we considered the placement of gravel pads of different thicknesses onto the ground surface. These experiments provide information on the degree of vulnerability of different parts of the North Slope to such disturbances.

3.6.2. PROGRESS

For this study, we enhanced the Geophysical Institute Permafrost Laboratory module and developed several high spatial resolution scenarios of changes in permafrost characteristics in the Alaskan Arctic in response to observed and projected climate change. The ground thermal properties of surface vegetation and the soil column were up-scaled using the Ecosystems of Northern Alaska map with a spatial resolution of 30 meters (Jorgenson and Heiner, 2004; Jorgenson et al., 2014). The assignment of ecosystem types provides a spatial decomposition of the study area with respect to hydrologic, pedologic, ground vegetation characteristics, and physical properties of the ground material. The ground thermal properties for each ecotype were recovered by assimilating temperature and snow measurement collected at the 12 GIPL and 16 U.S. Geological Survey (USGS) shallow boreholes (1–1.2 m in depth) throughout the North Slope region. The quality of the recovered ground properties was assessed by modeling the active layer thickness (ALT) at 22 Circumpolar Active Layer Monitoring (CALM) sites, as shown in Figure 3.6.3-1b. Generally, the modeling results agree very well with the observations. We employed a monthly averaged CRU TS3.1 dataset (Harris et al., 2014) downscaled by the Scenarios Network for Alaska and Arctic Planning (SNAP) group to a 770-m resolution. For the future modeling runs with the IPCC RCP 4.5 and 8.5 scenarios (Moss et al., 2008), we used an average composed of downscaled monthly averaged outputs of five GCMs (NCAR-CCSM4, GFDL-CM3, GISS-E2R, IPSL-CM5A-LR, and MRI-CGCM3) that optimally performs for Alaska (Walsh et al., 2008).

The model projected the mean annual ground temperature (MAGT), active layer thickness (ALT), and talik thickness into the future for RCP 4.5 and 8.5 scenarios. Taliks are unfrozen soil horizons between the bottom of the active layer and the top of the permafrost table. For the RCP 8.5 scenario, we find that ALT, up to 0.5 m (on average, in 2000) increases by a factor of two by 2050. From 2050 to 2100, according to the RCP 8.5 scenario,

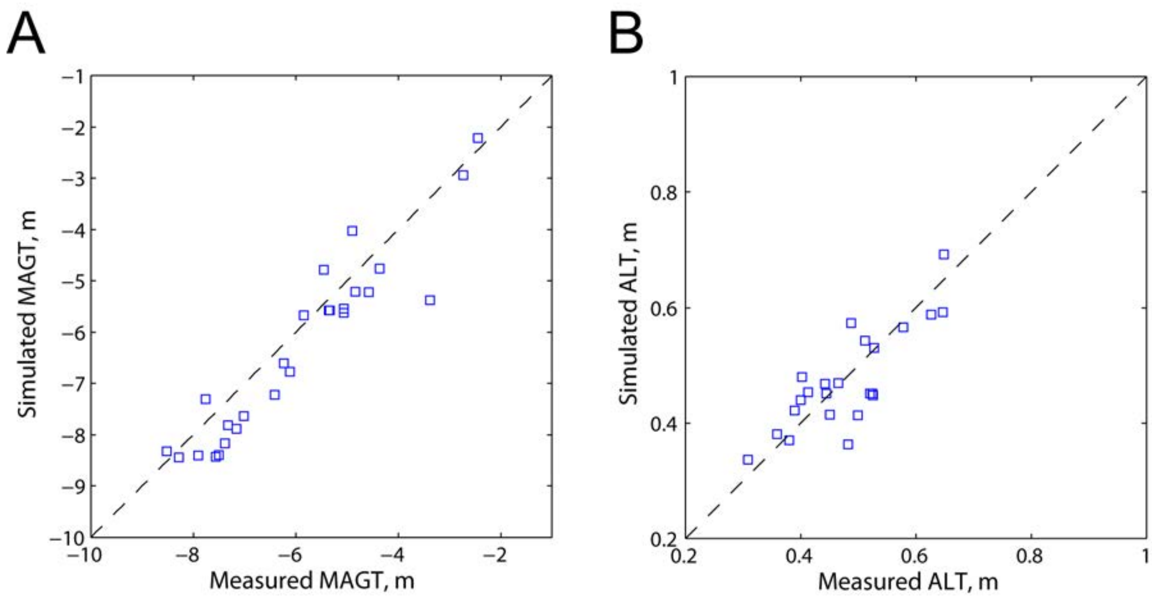


Figure 3.6.2-1. Comparison of the mean modeled and observed MAGT (A) and ALT (B) at the sites within the study region. Each rectangle is associated with the site, where the measurements are available.

ALT continues to increase and wide spread taliks start to form in the Alaska North Slope region, as illustrated in Figure 3.6.2-2. On the other hand, for the RCP 4.5 scenario, the current model predicts only a modest increase in the near-surface permafrost temperatures and a limited degradation of the near-surface permafrost in the Alaska North Slope region.

The model allows stakeholders to assess the impact of climate warming of existing or to-be-developed infrastructure for possible mitigation of an increase in maintenance expenses. To illustrate this capability, we modeled a potential increase in taliks for gravel pads with thickness of 0.6 m (2 ft), 1.2 m (4 ft) and 1.8 m (6 ft), as shown in Figure 3.6.2-3. We emphasize that the development of taliks in undisturbed conditions (the last row in Figure 3.6.2-2) will have serious implications for ecosystems, hydrology, and animal habitats, all of which will impact subsistence lifestyles, while the development of taliks under the gravel pads will impact infrastructure and increase maintenances expenses.

3.6.3. NEXT STEPS

In the coming year, we will further experiment with the developed model (a paper has been submitted to the Journal of Geophysical Research) and will conduct simulations to estimate the impacts of various changes in ground conditions, e.g. an increase in the future vegetation cover, changes in snow precipitation, and gravel pads with styrofoam insulation. We also plan to develop maps of potential subsidence due to the thawing of ice complexes.

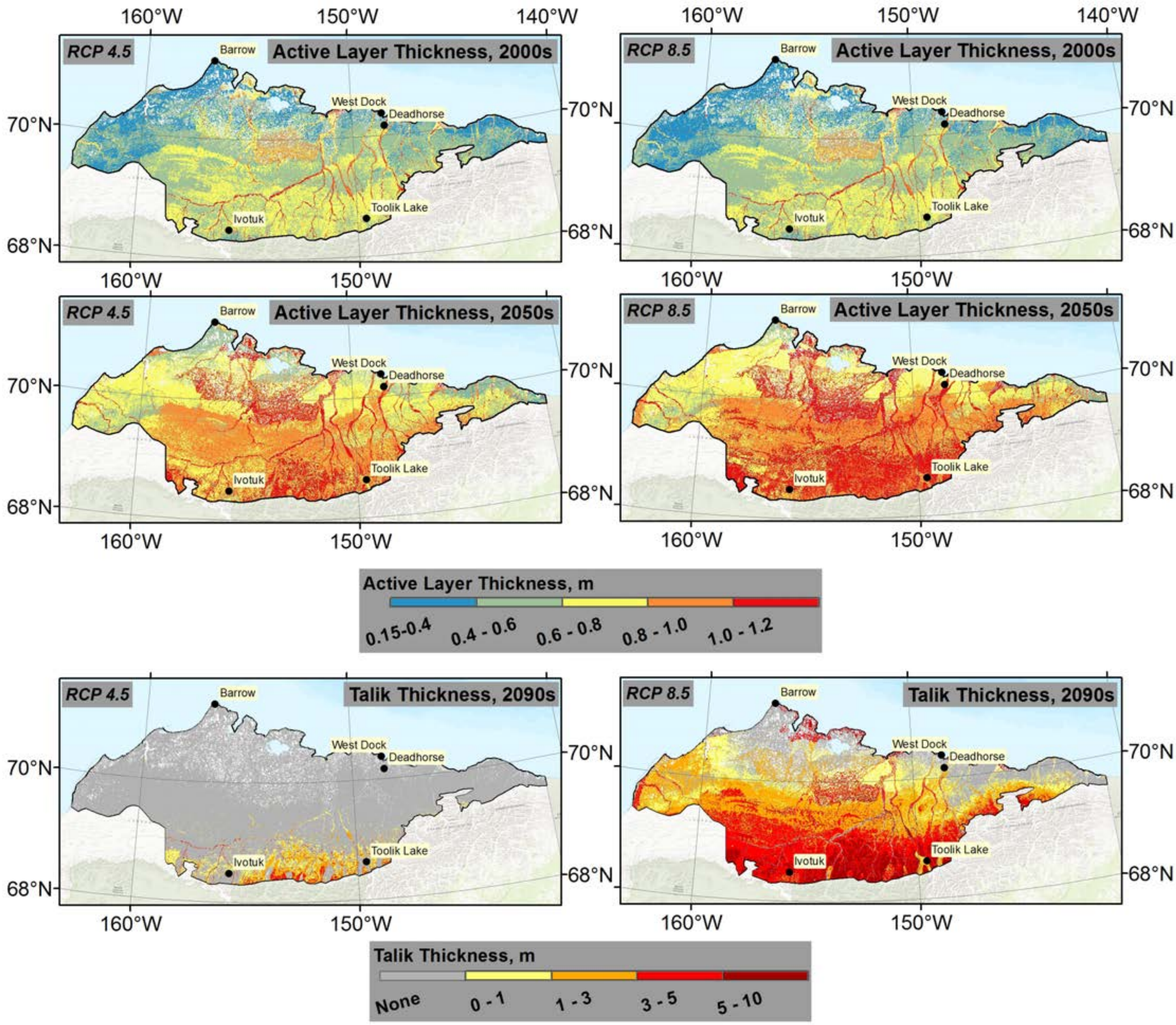


Figure 3.6.2-2. Maps of the modeled ALT and talik distributions for the RCP 4.5 (left) and RCP 8.5 (right) scenarios. The year is stated at the top right corner of each plot. The results for the RCP 4.5 and 8.5 scenarios illustrate a drastic difference in the future near-surface ground temperature regimes in 2050s and 2090s. For the RCP 8.5 scenario, we find that ALT, up to 0.5 m on average in 2000 increases by a factor of two by 2050. From 2050 to 2100, according to the RCP 8.5 scenario, ALT continues to increase and wide spread taliks starts to form in the Alaska North Slope region.

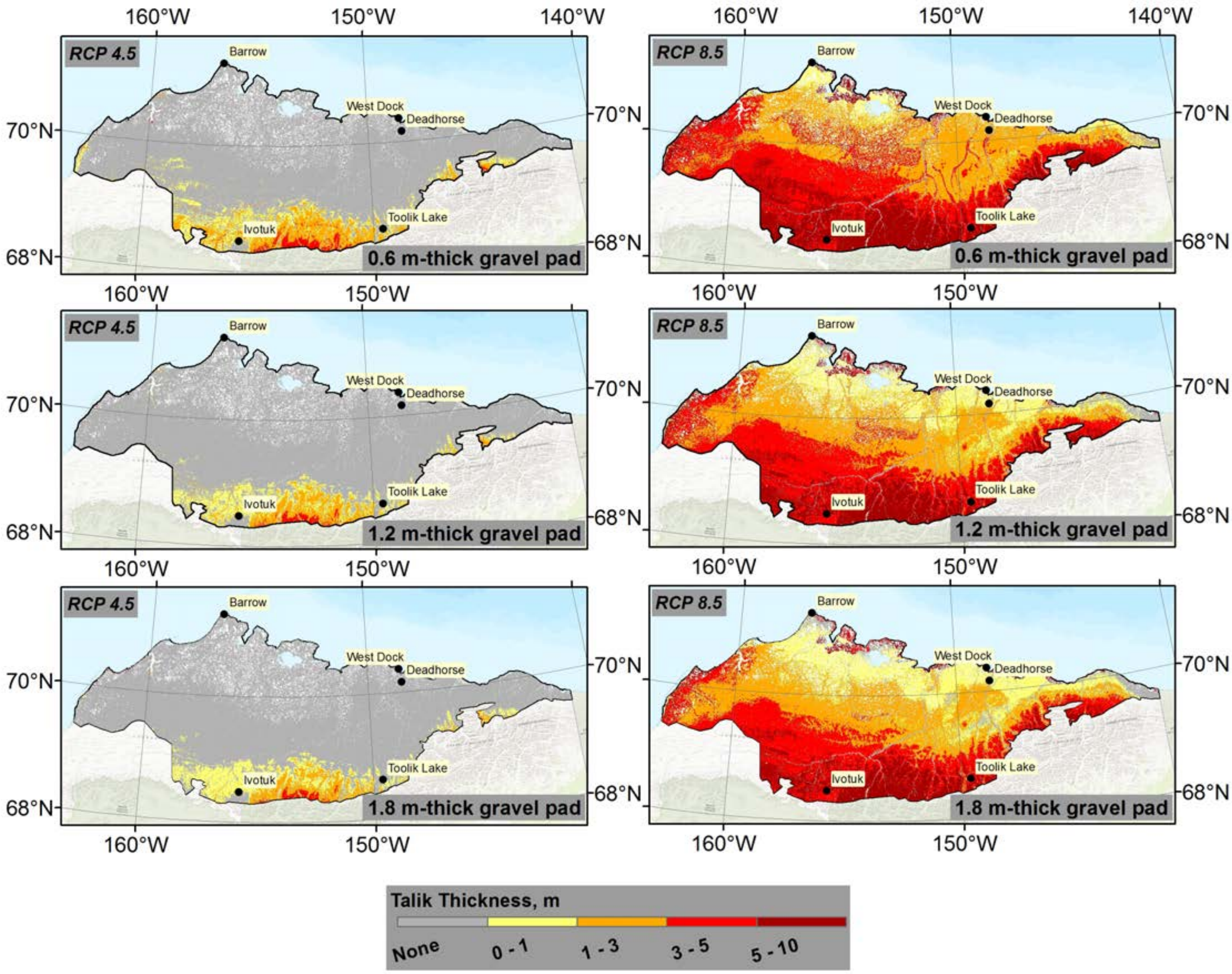


Figure 3.6.2-3. Modeled thickness of taliks under the hypothetical gravel pads constructed in the North Slope region in 2015 for RCP 4.5 (left) and RCP 8.5 (right) scenarios; the gravel pad thickness is stated in the lower right corner of each plot. Development of the taliks will have serious implications for human activities (infrastructure on the gravel pads). Placements of 1.8 m thick gravel pads (the last row) can help to mitigate an impact of the future climate warming along the Arctic shore by limiting development of the taliks under such gravel pads.

3.7. THERMOKARST DYNAMICS

The development of a thermokarst model capable of predicting landscape-level dynamics of thermokarst disturbance across the IEM domain was a major research effort in this phase of the IEM project. Landscape-level thermokarst dynamics were deemed to be important for the following reasons: 1) subsidence associated with the thawing of ice-rich permafrost can result in substantial changes in vegetation and habitat; and 2) thermokarst disturbance is closely tied to the distribution of wetland complexes, a common feature within the IEM model domain. Changes to the structure and function of wetlands has the potential to affect animal species that depend on these wetland complexes. To our knowledge, no large-scale model has been developed to predict landscape evolution in a thermokarst susceptible environment. Because lowland thermokast processes affect landscape evolution differently in tundra landscapes with massive ice wedges than in boreal landscapes with ice-rich silt, there is need to separately develop modules for these different landscape evolution contexts. Here we describe four components of the thermokarst dynamics research in this phase of the IEM project: (1) the general development of the ATM in the context of the IEM, (2) the development of the tundra module of the ATM, the development of land cover for the arctic coastal plain to be used to drive the tundra module of the ATM, and (4) the development of the boreal module of the ATM.

3.7.1. ALASKA THERMOKARST MODEL DEVELOPMENT

3.7.1.1. PROPOSED ACTIVITIES

The primary goal of the thermokarst research for this phase of the IEM project was to develop a model (the ATM) to track transitions among thermokarst and non-thermokarst landscape units. The ATM is intended to inform resource managers on potential changes in landscape and habitat due to changes in climate/thermokarst and to provide feedback to the IEM model of changes in the landscape that would affect hydrologic, ecologic and biogeochemical processes. The ATM has been designed as a stand-alone prototype model and will be coupled into the IEM framework during the next phase of the project.

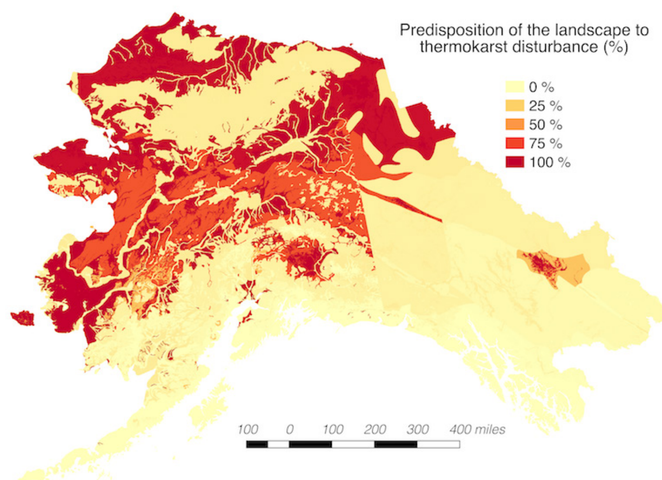


Figure 3.7.1.2-1. Map quantifying the proportion of the landscape predisposed (i.e., susceptible) to thermokarst disturbance at a 1-km resolution across the IEM spatial domain.

3.7.1.2. PROGRESS

We have made progress on two activities: (1) the development of a thermokarst predisposition/susceptibility model to help define the proportion of the landscape potentially susceptible to permafrost disturbance (Figure 3.7.1.2-1, available at http://ckan.snap.uaf.edu/is/dataset/thermokarst-formation), and (2) the development of the Alaska Thermokarst Model (ATM) for application in Alaska and northwest Canada to predict how the landscape evolves due to thermokarst disturbance associated with climate change. The ATM uses a frame-based methodology to track transitions among landscape units. Specifically, this methodology uses a logical rule set to calculate the probability that a landscape unit will remain in its current state or transition to a new landscape unit. The set of rules in this framework have been developed from literature review and expert assessment to represent the environmental drivers of thermokarst formation in the arctic (see sections 3.7.2 and 3.7.3 below)and the boreal regions (see section 3.7.4 below) separately.

These sets of rules have been converted into a functional, modular python (computer language) code written to handle input data (as geotiffs) on climate, fire regime, land cover distribution, permafrost distribution and active layer depth, and soil characteristics. The ATM currently operates in a stand-alone model, but has been designed to be readily coupled into the existing IEM framework, i.e. the I/O from ATM matches the data definition, unit and resolution currently in use in the

IEM Framework. The development version of the ATM code is publicly available (https://github.com/ua-snap/atm). The model is currently being tested in the Barrow Peninsula in the arctic region, and in the Yukon Flats and the Tanana Flats in the boreal region. For these test areas, new land cover maps have been developed and will be used to initialize model simulations.

3.7.1.3 NEXT STEPS

In the next phase of the IEM project, the ATM will be applied outside of the original test areas, in all Interior Alaska and the entire Arctic Coastal Plain. The ATM will also be dynamically coupled to the IEM framework to represent the effect of thermokarst dynamics on hydrology, vegetation composition, permafrost dynamics, and biogeochemical and biogeophysical processes. Information on fire regime and land cover distribution will be provided by ALFRESCO. Information on permafrost and active layer depth will be provided by GIPL. Soil structure information will be provided by DVM-DOS-TEM. The outputs generated by the model provides information on an annual basis about land cover composition and age distribution within a 1km-resolution grid (Figure 3.7.1.3-1). Using historical climate data (1901-2009) to drive the model, we will evaluate and validate the ATM through comparison of simulated rates of land cover change to estimated rates of land cover change derived through field studies and remote sensing analyses.

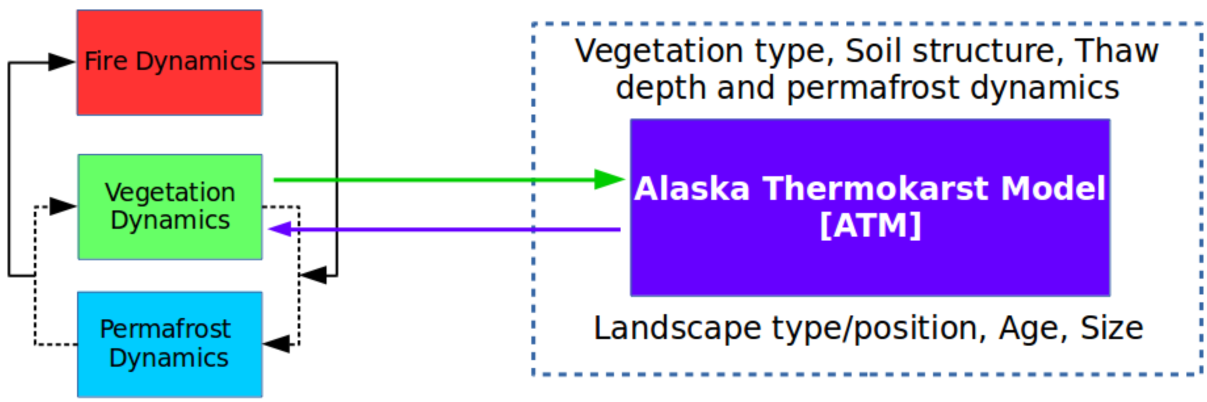


Figure 3.7.1.3-1. The proposed interactions between the IEM components (left panel) and the ATM (right panel). Currently, the ATM is a stand-alone model (indicated by dashed lines) and has a simplified representation of processes and variables that will provided to the ATM by the IEM. When coupled, the ATM will receive information on vegetation type, soil structure, thaw depth and permafrost dynamics. The ATM will provide landscape information (position, age, and size of landform) to the IEM.

3.7.2. ARCTIC TUNDRA THERMOKARST DYNAMICS

3.7.2.1. PROPOSED ACTIVITIES

Many Arctic Coastal Plain bird species depend on the availability of open water. Small changes in the landscape, caused by the degradation of ice-wedge polygons, can impact the landscape's ability to retain water (Liljedahl et al., 2012). To help predict potential changes in the availability of open water, the development and application of a landscape evolution model that tracks thermokarst transitions due to ice-wedge degradation in the arctic tundra environment was proposed for this phase of the IEM project. The Barrow Peninsula was selected as the study area to build and test the arctic tundra module of the ATM.

3.7.2.2. PROGRESS

The arctic tundra module of the ATM is designed to track landscape positions associated with the ice-wedge polygon development and degradation within wetland tundra, graminoid tundra, and shrub tundra ecotypes (Figure 3.7.2.2-1). In our conceptualization and implementation of landscape evolution in the arctic tundra environment, the thermokarst process is initiated when the active layer (the thin soil layer that seasonally freezes and thaws above permafrost) increases beyond the protective layer (the seasonally maximum depth of the active layer, which acts as a buffer between surface processes and permafrost) and taps into ice-rich soils. The thawing of permafrost can result in thermokarst pits, the transition from non-polygonal ground to high centered polygons, and lake (shallow or deep) formation. The distinction between shallow and deep lakes is determined by the presence or absence of liquid water throughout the year (shallow lakes completely freeze to the bottom while deep lakes have some fraction of liquid water throughout the winter period).

The infrastructure (computer coding that simulate transitions between 15 distinct landscape types) for the ATM has been developed for the Barrow Peninsula. After completion of the initial coding, the following events led to a substantial reworking of the ATM: 1) In October 2015, the ATM was presented at a webinar hosted by the Arctic LCC and included a number of participants from the USFWS and USGS Alaska Science Center. The discussion following the webinar led to the decision to expand the landscape types to distinguish small, medium, and large lakes (lake size is an important factor in bird habitat models); 2) the Lara et al. (2014) paper showed relative age to be an important factor in the rate of change of landscapes with younger landforms evolving more quickly than older landforms. As a result, we also decided to include the relative age (young, medium, old) of the landscape types; and 3) the work completed as part of the Arctic Landcover Project (described in section 3.7.3 below) included a number of additional landscape types beyond the those resulting from ice-wedge degradation on the Barrow Peninsula. As the spatial domain of the Arctic Landcover Project includes the Barrow Peninsula, the decision was made use the Barrow Peninsula as the test region for the arctic module of the ATM using the landcover types that were produced for the Arctic Landcover Project to avoid duplication of effort. The combined effect of these three events as well as consultation with the Arctic LCC about the number of landscape types needed to effectively represent heterogeneity in bird habitat has led to an expansion from 15 landscape types to 43 distinct landscape types. While the number of landcover types has been expanded, our focus remains on simulation of landscape evolution resulting from aggradation/degradation of ice-wedge polygons and adequately validating the model in this context.

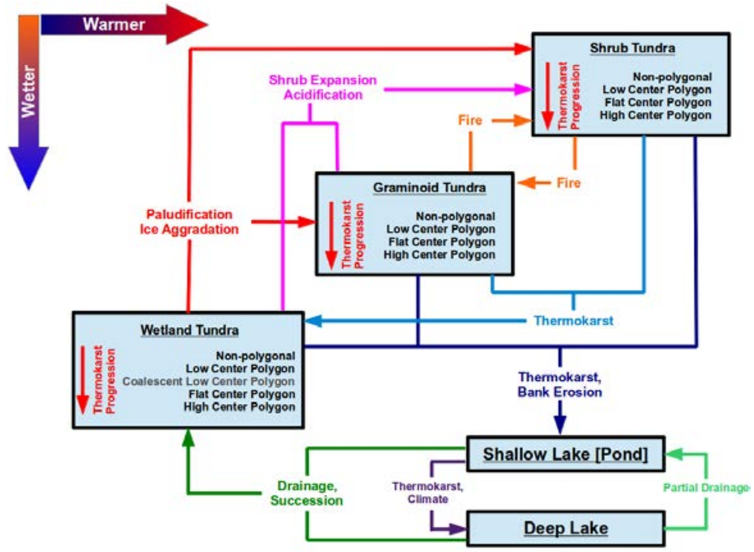


Figure 3.7.2.2-1. Arctic tundra thermokarst frame. The three major arctic tundra terrestrial ecotypes – wetland tundra, graminoid tundra, and shrub tundra – as well as the lake ecotypes are presented in square boxes. The processes that would lead to shifts between these ecotypes are indicated with the connecting arrows. Within each of the terrestrial ecotype boxes, the landscape position and sequence of changes due to thermokarst are shown.

3.7.2.3. NEXT STEPS

In the next phase of the IEM project, the infrastructure of the arctic module of the ATM will be completed and assessed in the Barrow Peninsula area (including both terrestrial changes and lake expansion/drainage events) from existing field studies and analyses of historical remote sensing data. Scenario simulations will then be conducted for the Arctic Coastal Plain (using the same domain area described in section 3.7.3 below).

3.7.3. ARCTIC LAND COVER PROJECT

3.7.3.1. PROPOSED ACTIVITIES

Historically, due to technical remote sensing challenges and data limitations, nearly all polygonal tundra geomorphology or patterned ground maps in arctic regions are manually delineated for small study regions. Therefore, little is known about the spatial distribution of polygonal tundra geomorphology, which is highly vulnerable to change associated with thermokarst related processes across. In this initiative, we sought to create and validate the first polygonal tundra geomorphology map for the Arctic

Coastal Plain of Alaska, at a spatial resolution of 30 x 30 meters, which would represent the first fully automated approach for characterizing the spatial patterns of polygonal tundra geomorphology in arctic tundra ecosystems. This product is essential for the arctic ATM which will initialize land cover distribution and facilitate state transitions in the ATM between terrestrial ecotypes (see earlier section 3.7.2.2 and earlier Figure 3.7.2.2-1).

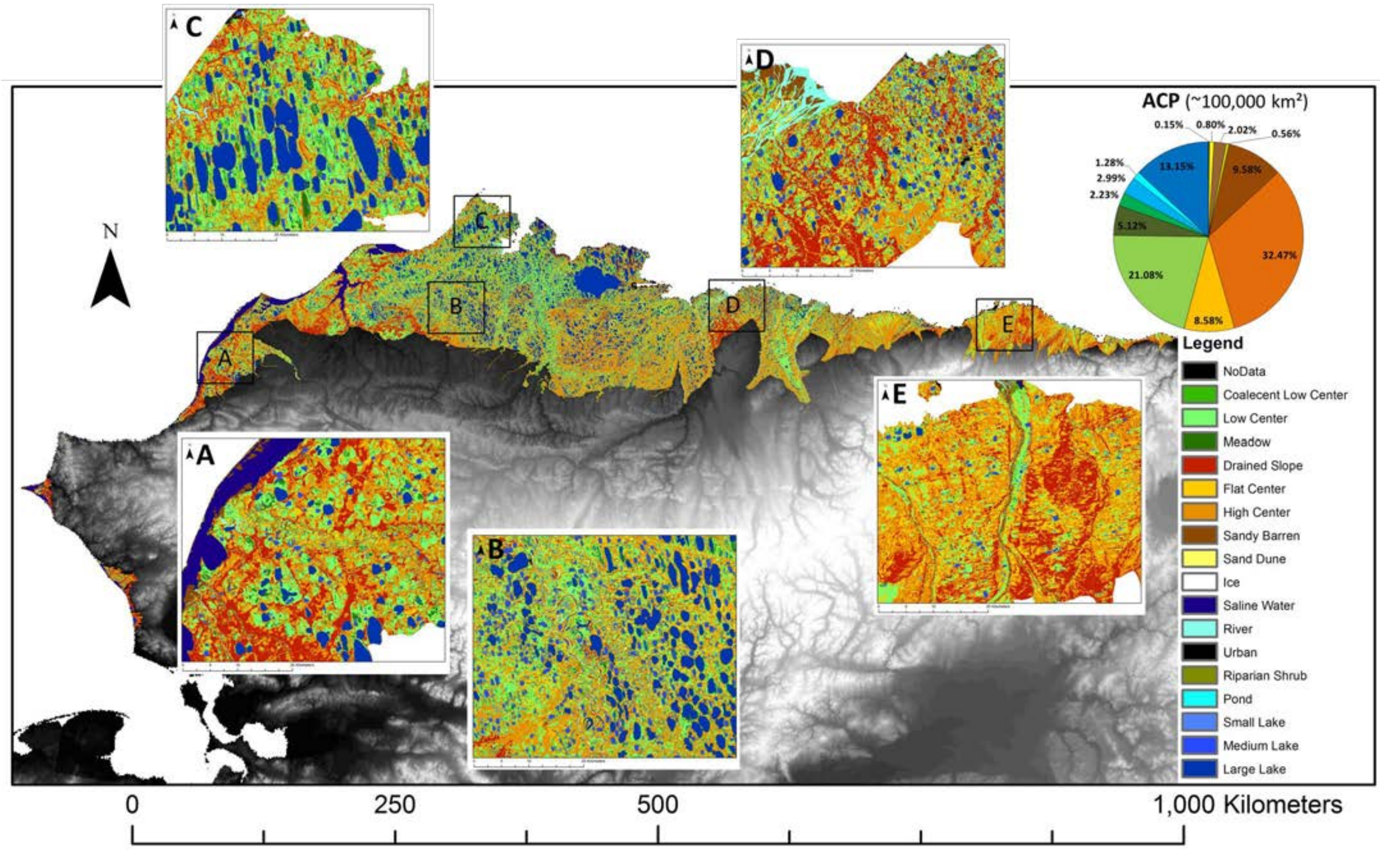


Figure 3.7.3.2-1. Alaskan Arctic Coastal Plain Geomorphology Map was created at 30 x 30 m spatial resolution. Panels A-E are regionally enlarged subsections of the ACP spanning ecoregions from east to west and representing both Arctic Peaty Lowlands and Arctic Sandy Lowlands. Map products are projected on a 600 m Digital Elevation Model.

3.7.3.2. PROGRESS

We mosaicked twelve LandSat-8 satellite images taken during the summer of 2014, which were used in an object based image analysis to classify the landscape. We mapped seventeen of the most dominant geomorphic land cover classes on the Arctic Coastal Plain: (1) Coastal saline waters, (2) Large lakes, (3) Medium lakes, (4) Small lakes, (5) Ponds, (6) Rivers, (7) Meadows, (8) Coalescent low-center polygons, (9) Low-center polygons, (10) Flat-center polygons, (11) High-center polygons, (12) Drained slope, (13) Sandy barrens, (14) Sand dunes, (15) Riparian shrub, (16) Ice, and (17) Urban (i.e. towns and roads). Mapped products were validated with an array of oblique aerial/ground based photography (Jorgenson et al., 2011) and 249 high resolution SPOT-5 images covering >80% of the ACP. We used a stratified random sampling accuracy assessment design, where peaty and sandy lowlands contained 700 and 300 reference sites, respectively. Overall map accuracy was 76% and Cohen's Kappa coefficient was 0.73. The Alaskan Arctic Coastal Plain Geomorphology map (Figure 3.7.3.2-1) estimates high center polygons, low center polygons, and Lakes, to be the most dominant land cover types on the ACP, representing 32, 21, and 13%, respectively.

3.7.3.3. NEXT STEPS

As highlighted earlier in section 3.7.2.3, in the next phase of the IEM project, subsections of this map (i.e. Barrow Peninsula) will be used to refine ATM processes and development and will then be used in scenario simulations that will be conducted for the Arctic Coastal Plain.

3.7.4. BOREAL FOREST THERMOKARST DYNAMICS

3.7.4.1. PROPOSED ACTIVITIES

The development, testing and application of a predictive model of thermokarst dynamics for the boreal region was proposed for this phase of the IEM project. This model has been designed to simulate vegetation dynamics associated with the lateral thaw of permafrost plateaus and will be applied in Interior Alaska and the boreal region of Northwestern Canada to assess thermokarst dynamics in response to historical and project climate change. The consequences of thermokarst disturbance on ecosystem structure and function will be evaluated by integrating the ATM into the IEM framework.

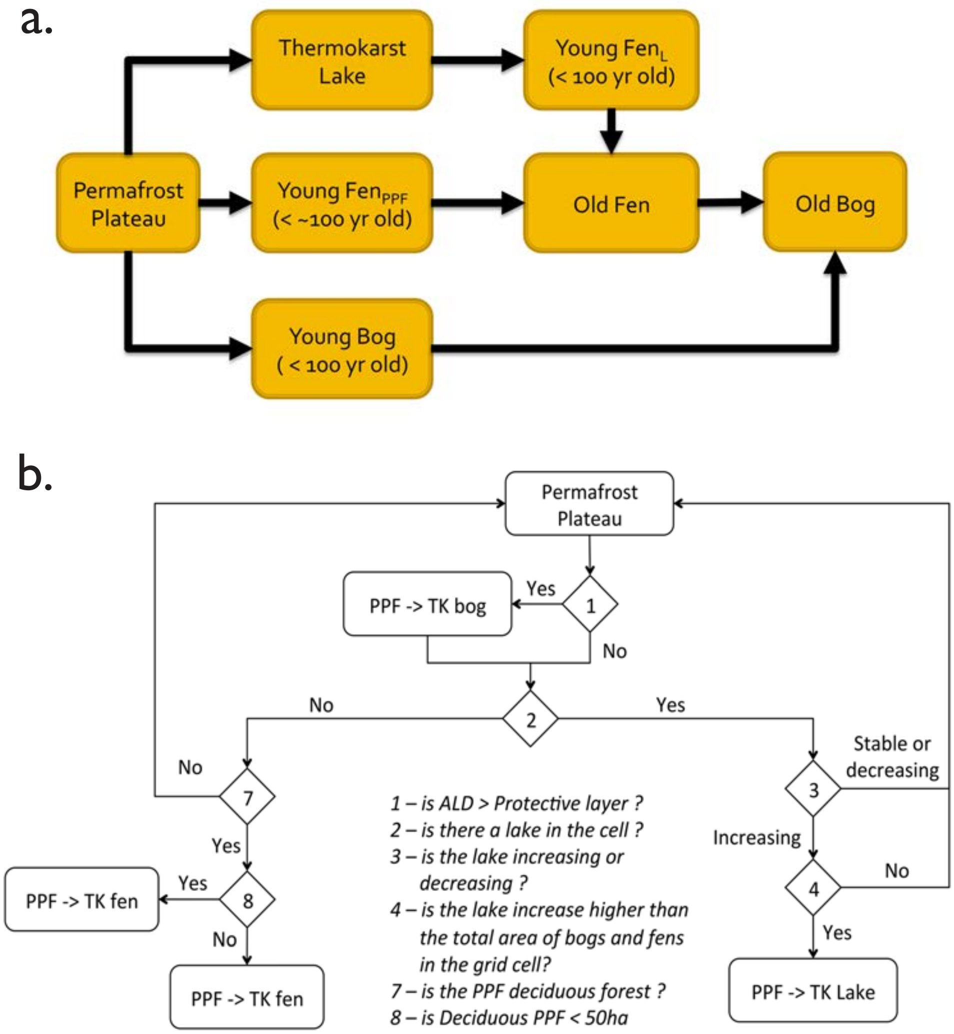


Figure 3.7.4.2-1. (a) Diagram representing the land cover trajectories associated with thermokarst disturbance in the ATM for the boreal region, (b) set of rules associated with lateral thaw of permafrost plateau forest.

3.7.4.2. PROGRESS

The thermokarst model for the boreal region represents the environmental drivers triggering the development of three main thermokarst features commonly found in boreal regions (Jorgenson et al. 2001): thermokarst lakes, collapse scar bogs, and collapse scar fens (Figure 3.7.4.2-1a). Thermokarst dynamics are driven by a set of rules (one set for each land cover type) representing the effect of climate, active layer dynamic, fire regime, hydrology, vegetation composition and age, soil texture and geology and permafrost ice content on the timing and rate of thermokarst formation as well as the type of landscape transition that could occur (see example in Figure 3.7.4.2-1b).
Model formulation and parameterization has been based on literature review (e.g. Roach et al. 2013, Jorgenson et al. 2005) and a new repeated imagery analysis conducted in the Tanana Flats documenting how thermokarst-driven transitions have been accelerating over the past four decades and what environmental drivers are triggering permafrost lateral degradation (Lara et al. 2016).

To initialize model simulations, new land cover maps have been developed from a cross walk with the 2001 land cover map from the National Land Cover Database (Figure 3.7.4.2-2, Homer et al. 2007) to explicitly locate the land cover types defined in the ATM (shrubland, deciduous and evergreen permafrost plateau, lake, bog and fen).

3.7.4.3. NEXT STEPS

As part of the next phase of the IEM project, ATM simulations for the boreal region will be validated using existing and new repeat imagery analysis quantifying historical land cover change in Interior Alaska and Northwestern Canada.
The model is currently being applied in the two test-areas selected for the boreal region, i.e. the Yukon Flats and the Tanana Flats, for the historical period [1950-2009] and projections from 2010 to 2099, using the new climate datasets generated by the data group (see section 3.1).

Once the ATM is coupled with the IEM framework, the model will also be applied across the entire boreal region of the

IEM domain. The effect of thermokarst disturbance on the regional fire regime and carbon balance will be evaluated by comparing model outputs with simulations of the IEM framework in which thermokarst disturbance was not represented. Finally, we will develop and apply a resource impact model to assess how thermokarst dynamics affects wildlife habitat in boreal regions. This last activity will be primarily supported by a USGS-funded project in the Yukon Flats.

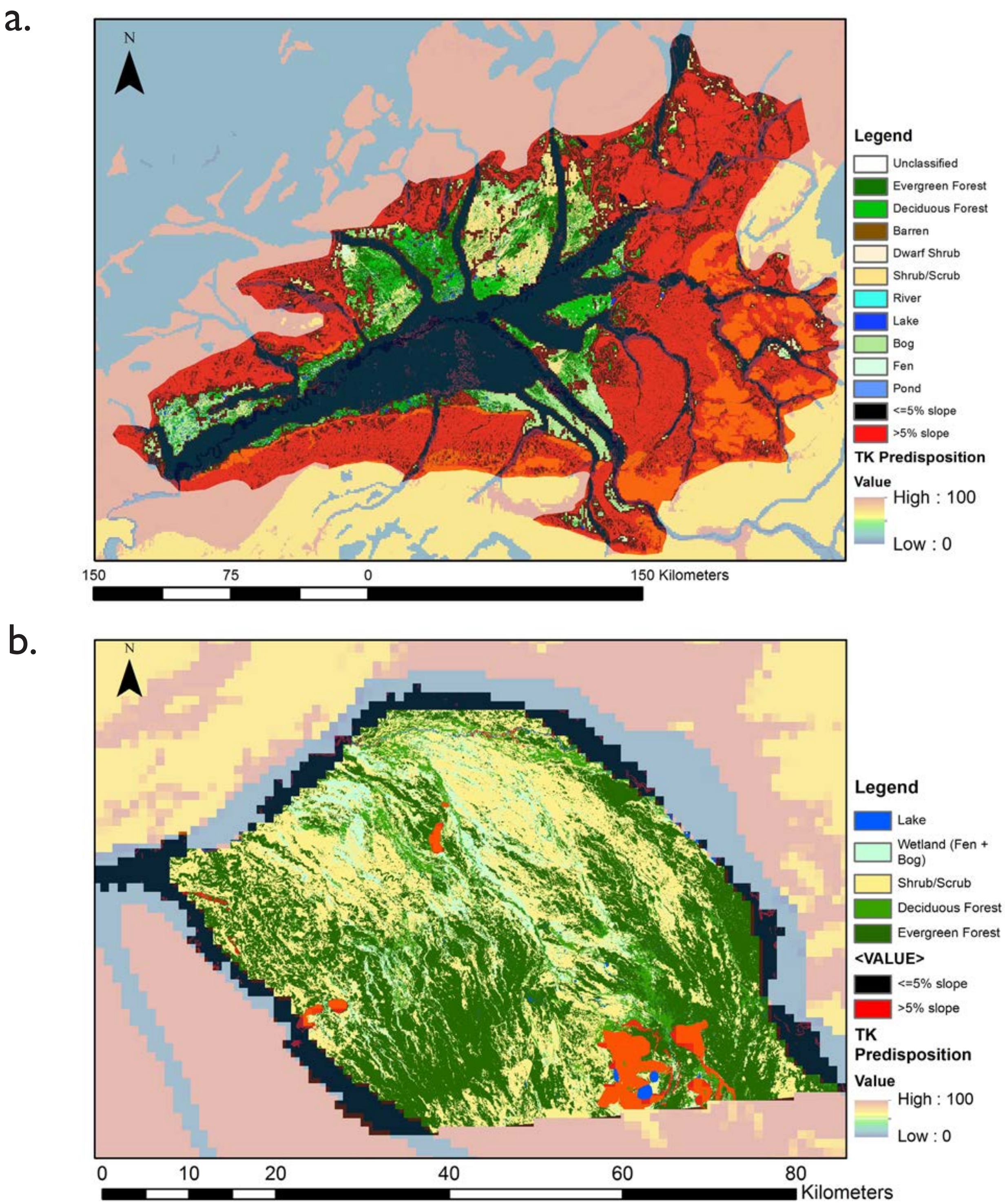


Figure 3.7.4.2-2. New land cover map used for initialization of the ATM simulations in the two test areas, a) the Tanana Flats and b) the Yukon Flats.

3.8. WETLAND DYNAMICS: FIELD-BASED RESEARCH

3.8.1. PROPOSED ACTIVITIES

We continued our collaboration with Dr. Waldrop's (USGS Menlo Park) field program studying wetland dynamics. These field studies consist of conducting flux scaling studies at the Alaska Peatland Experiment (APEX), where work has been ongoing since 2005. These studies have been conducted to support the wetland dynamics modeling research (see section 3.9 below).

3.8.2. PROGRESS

The data from eddy covariance flux towers examining seasonal and interannual controls of carbon, water, and energy fluxes across a range of permafrost conditions (Euskirchen et al., 2014), combined with continued studies of nitrogen (N) availability (Finger et al., 2016), and water table manipulations (Olefeldt et al., in review), has provided new information on scaling, sources of carbon dioxide (CO_2) and methane (CH_4) flux, and edaphic and biotic controls on wetland processes. Data from the eddy covariance sites indicate that the net ecosystem exchange (NEE) of a rich fen, thermokarst collapse scar bog, and black spruce forest is sensitive to hot, dry conditions (Euskirchen et al., 2014). We find large amounts of interannual variability in net ecosystem exchange at the thermokarst collapse scar bog, ranging from a source of 126 g C m-2 in 2014 to a sink of -83 g C m-2 in 2012 (Figure 3.8.2-1). Methane emissions varied across the sites, with largest emissions of CH_4 in the rich fen and collapse scar bog and little from the black spruce forest (Figure 3.8.2-2). Studies of N availability indicate that the conversion of forest to wetlands associated with permafrost thaw in boreal lowlands increases N availability, at least in part by increasing turnover of deep soil organic matter (Finger et al., 2016). Long-term carbon flux data from water table manipulations at the rich fen suggests that there are lag effects of droughts seen in a treatment with a lower water table: GPP, ER and NEE remained suppressed in wet years following prolonged droughts (Olefeldt et al., in review).

3.8.3. NEXT STEPS

We will continue to measure carbon, water, and energy fluxes and their response to changing climatic conditions at the boreal APEX sites. We will also continue to investigate how changes in N availability with permafrost thaw may influence ecosystem dynamics at these sites. We will explore the possibility of installing an additional eddy covariance flux tower at an older permafrost collapse scar bog than the one that we are currently measuring to further understand how carbon, water, and energy fluxes change with time since thaw.

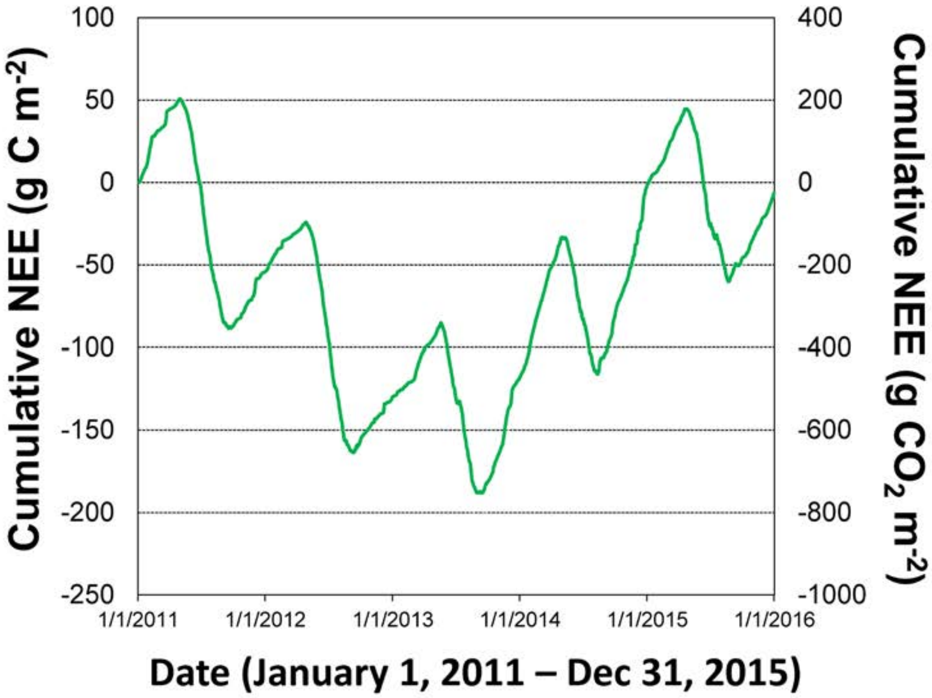


Figure 3.8.2-1. Cumulative NEE at the thermokarst collapse scar bog from 2011 – 2015.

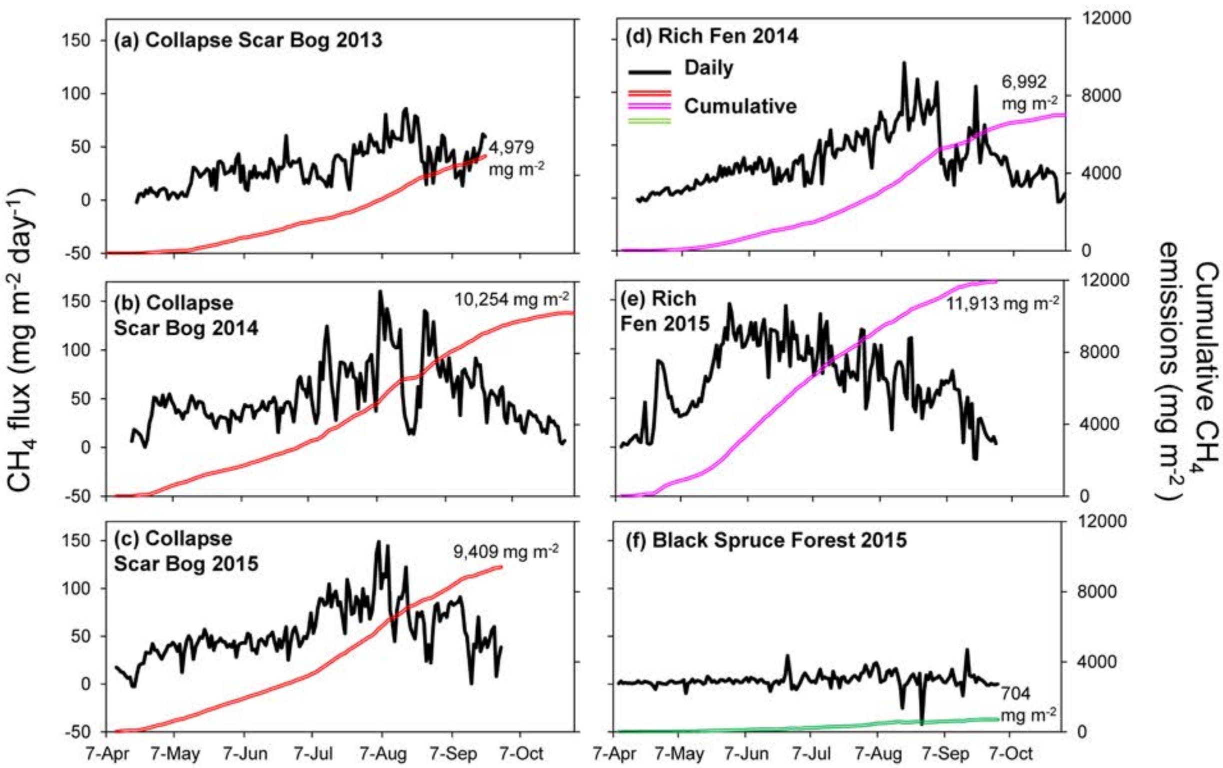


Figure 3.8.2.-2. Methane emissions across the rich fen, thermokarst collapse scar bog and black spruce forest.

3.9. WETLAND DYNAMICS: MODEL-BASED RESEARCH

3.9.1. PROPOSED ACTIVITIES

The goal of the model-based research of the wetland dynamics activity was to model the biogeochemical and successional dynamics of wetland types in Alaska. This research is based, in part, on the field studies described in section 3.8.

3.9.2. PROGRESS

We primarily focused on modeling the biogeochemical dynamics of two wetland types being studied as part of the field-based research component of the wetland dynamics activity (see section 3.8 above): (1) collapse-scar fens and (2) collapse-scar bogs. The primary tool we developed as part of this activity was peatland DOS-TEM (PDOS-TEM), which built upon the version of DOS-TEM that we had developed in previous phase of the IEM project (Yuan et al. 2012). This required adding a peatland organic carbon module to DOS-TEM (Figure 3.9.2-1). This module tracks water table so that aerobic biogeochemical processes occur above the water table and anaerobic biogeochemical processes occur below the water table. After developing and integrating this module into PDOS-TEM, we applied the model to synthesize the results of a field water table manipulation experiment that was conducted in a boreal rich fen to understand how soil organic carbon and soil CO_2 and CH_4 fluxes might respond to projected climate change. Our approach was to calibrate the model based on data from the control treatment of the manipulation experiment, and to assess the model based on the data from two experimental treatments, including raised and lowered water table manipulations. The model was then used to simulate soil organic carbon (SOC) dynamics (i.e., C inputs into the soil, CO_2 and CH_4 exchange with the atmosphere, and changes in soil C stocks) of the control treatment under various CO_2 emission scenarios (high, midrange, and low emissions). The full description of PDOS-TEM and its application to the rich fen is included in Fan et al. (2013). We next parameterized and applied the model to the collapse-scar bog being studied in the wetland field program (Mi et al., in preparation). Collapse-scar bogs are a type of peatland that are formed by the thaw of permafrost in forested peatlands and subsequent subsidence. Comparison with field-based estimates shows that PDOS-TEM performs well in simulating the C fluxes and pools of the collapse-scar bog study site. Under future climate and atmospheric CO_2 concentration scenarios (2014-2100), our analysis indicates that the site will act as carbon sink for CO_2 but that CH_4 emissions will increase nearly two fold. Our analysis of the cumulative radiative forcing indicates that this bog will act to enhance warming by 1.68 to 2.04 W m-2 between 2014 and 2100 because of the increase in CH_4 emissions (Figure 3.9.2-2).

3.9.3. NEXT STEPS

Now that PDOS-TEM has been developed, it needs to be integrated with DVM-DOS-TEM so that it can represent individual plant functional types in wetlands. The idea is that PDVM-DOS-TEM will be responsible in the IEM for simulating the biogeochemical and successional dynamics of wetlands. This is an important precursor to coupling the thermokarst model into the IEM (see Figure 3.7.1.3-1 above).

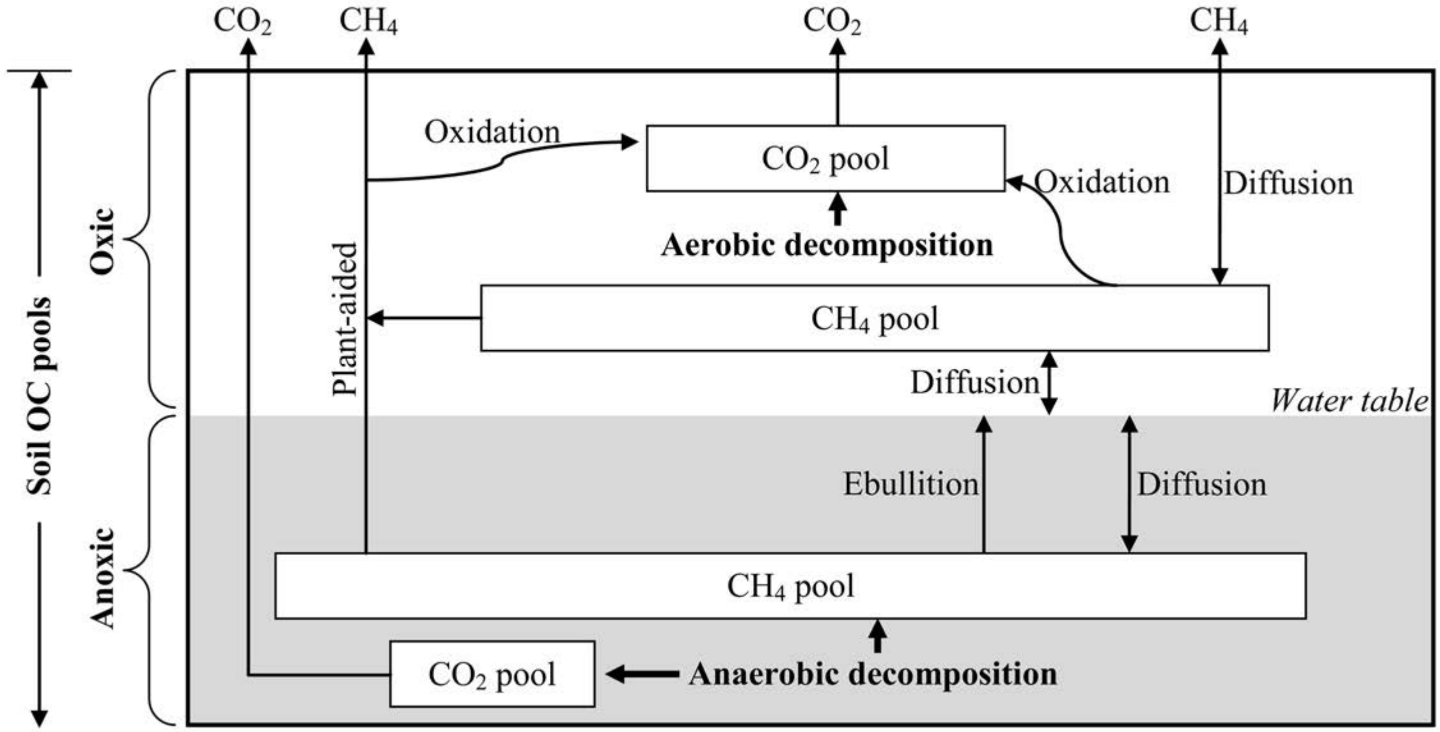


Figure 3.9.2-1. Schematic of the peatland organic carbon module in PDOS-TEM.

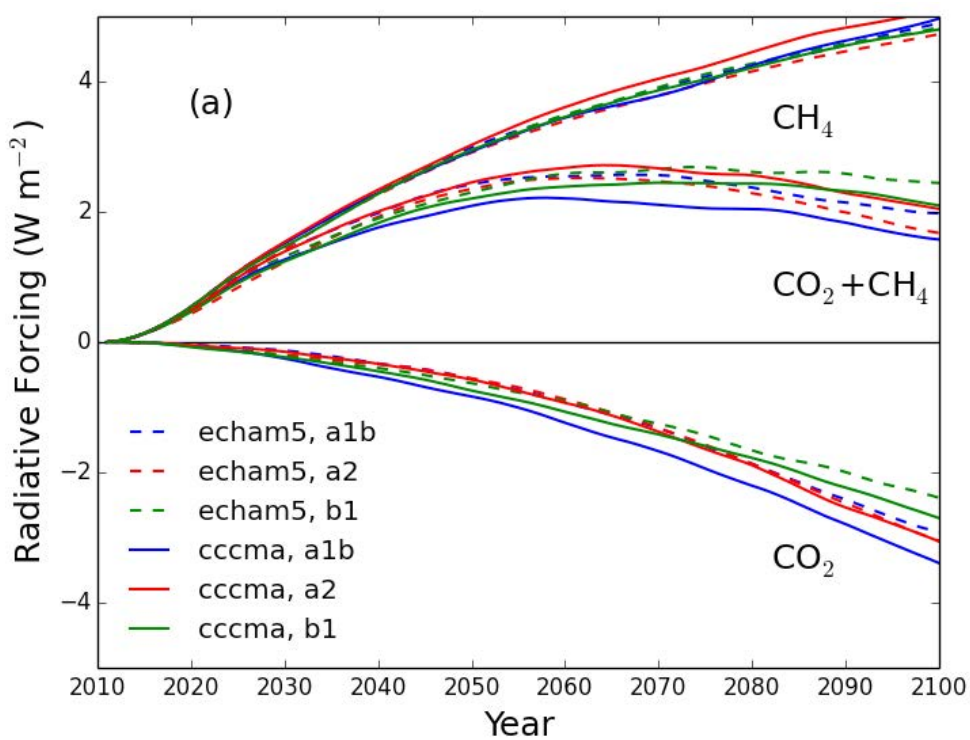


Figure 3.9.2-2. Changes in cumulative radiative forcing calculated based on the CO_2 and CH_4 flux predicted by PDOS-TEM for a collapse scar bog in interior Alaska, under projected climate and atmospheric CO_2 concentration conditions of high emission (A2), low emission (B1), and midrange emission (A1B) scenarios from two global circulation models (CCCMA and ECHAM5), 2014-2100.

SECTION 4.
PRODUCTS

This section documents the products produced by the project in the following categories: (1) data sets, (2) publications, and (3) presentations at scientific conferences.

4.1. DATA SETS

PROJECT DATA DESCRIBED IN THE FOLLOWING TABLES ARE AVAILABLE AT:

www.snap.uaf.edu/projects/iem

Definitions of Data Types

The file format of IEM data products varies depending on the data type.

Spatial: GIS data (generally in raster .geotiff format or occasionally shape files)

Tables: A summarization of a metric over specific region (generally in .csv format for ease of use in spreadsheet or statistical programs).

Graphs: A time series of a metric across a region (generally in .png image file).

Code: Programming code of the models.

The models are driven by the MPI-ECHAM5/MPI-OM and CCCMA-CGCM3.1(T47) IPCC Fourth Assessment Report (AR4) climate models for the mid-range A1B emissions scenario for the Gen 1 DOS-TEM coupling. For the Gen 1 DVM-DOS-TEM and Gen 2 couplings, the models are driven by the IPCC Fifth Assessment Report (AR5) NCAR-CCSM4 and MRI-CGCM3 climate models focusing on RCP 8.5. Products are provided for the geographic extent of the IEM domain and on an annual time-step unless otherwise indicated.

Climate Products (e.g., temperature, precipitation, radiation, vapor pressure)

Dataset Name	Data Type	Description	Generation Model Output	Availability
Projected average monthly temperatures, precipitation, radiation and vapor pressure	Spatial	Downscaled projections of monthly temperature, precipitation, radiation and vapor pressure	Gen 1 - AR4	2012
			Gen 2 - AR5	2015
Historical average monthly temperatures, precipitation, radiation and vapor pressure (CRU)	Spatial	Downscaled projections of monthly temperature, precipitation, radiation and vapor pressure from the Climatic Research Unit (CRU) at the University of East Anglia time series (TS) datasets	Gen 1 and Gen 2	2012

Ecosystem Dynamics Products (e.g., carbon flux)

Dataset Name	Data Type	Description	Generation Model Output	Availability
Data from wetland field component of the IEM	Spatial (Site specific) Tables Graphs	Flux and environmental data collected from autochambers within a black spruce forest and thermokarst bog environment at the Alaska Peatland Experiment (APEX) within the Bonanza Creek Experimental Forest. Data are from 2012-2015.	NA	2016
Carbon fluxes and pools (ECHAM5 and CCCMA-A1B scenario)	Spatial Tables Graphs	Model output data related to carbon fluxes (GPP, Net Primary Productivity, decomposition, carbon released by fire) and carbon pools in soil and vegetation.	Gen 1 - AR4 DOS-TEM	2016
			Gen 1 - AR5 DVM-DOS-TEM	2016
			Gen 2 - AR5 DVM-DOS-TEM	August 2017 for Proof of Concept

Disturbance Products (e.g., area burned, burn severity, thermokarst)				
Dataset Name	Data Type	Description	Generation Model Output	Availability
Historical area burned	Spatial	Historical area burned.		2013
Area burned and burn severity (ECHAM5 and CCCMA-A1B scenario)	Spatial Tables Graphs	Model output of area burned and burn severity. Graphs and tables showing annual area burned through time.	Gen 1 - AR4 ALFRESCO	2015
			Gen 1 - AR5 ALFRESCO	December 2016
			Gen 2 - AR5 ALFRESCO	August 2017 for Proof of Concept
Relative flammability (ECHAM5 and CCCMA-A1B scenario)	Spatial	Derived product depicting relative flammability, which is the likelihood of a pixel to burn, summarized for three time periods (1900-2100, 1900-1999, and 2000-2099).	Gen 1 - AR4 ALFRESCO	2015
			Gen 1 - AR5 ALFRESCO	December 2016
			Gen 2 - AR5 ALFRESCO	August 2017 for Proof of Concept
Potential susceptibility to thermokarst	Spatial	Modeled data used to identify areas susceptible to thermokarst disturbance. Datasets may include contemporary fractional coverage of thermokarst/wetland landforms, distance from surface to ice rich permafrost, amount of ice in the soil column, drainage efficiency (parameter that describes the ability of the landscape to store water), and soil water content.		2014
Thermokarst disturbance on the Arctic Coastal Plain	Spatial Tables Graphs	Maps and graphs depicting land cover changes associated with thermokarst disturbance on the Arctic Coastal Plain.	ATM	April 2017
Thermokarst disturbance on the Tanana Flats	Spatial Tables Graphs	Maps and graphs depicting land cover changes associated with thermokarst disturbance on the Tanana Flats.	ATM	April 2017
Thermokarst disturbance on the Yukon Flats	Spatial Tables Graphs	Maps and graphs depicting land cover changes associated with thermokarst disturbance on the Yukon Flats.	ATM	April 2017

Landcover and Landscape Products (e.g., vegetation type, treeline extent, topography)

Dataset Name	Data Type	Description	Generation Model Output	Availability
Model input land cover	Spatial	Model input landcover for the IEM domain. This data layer is a greatly modified product derived from the "2005 Land Cover of North America at 250 meters, Edition 1.0" dataset produced as part of the North America Land Change Monitoring System (NALCMS). This data was developed as, and focused solely on, model input data requirements, which is a simplification of the landscape.	Version 0.2	2012
			Version 0.4, Southeast and Southcentral Alaska update	2015
Elevation, aspect, and slope	Spatial	Modeled elevation (m), aspect, and slope derived from elevation data developed by the PRISM climate group and distributed by ClimateSource via www.climatesource.com or www.prism.oregonstate.edu.		2012
Treeline extent (ECHAM5 and CCCMA-A1B scenario)	Spatial	Derived product depicting projected treeline migration.	Gen 1 - AR4 ALFRESCO	2015
			Gen 1 - AR5 ALFRESCO	December 2016
			Gen 2 - AR5 ALFRESCO	August 2017 for Proof of Concept
Vegetation distribution (ECHAM5 and CCCMA-A1B scenario)	Spatial Tables Graphs	Modeled distribution of six vegetation types (white spruce, black spruce, deciduous forest, graminoid tundra, shrub tundra, wetland tundra). Graphs and tables showing changes in area of vegetation types through time.	Gen 1 - AR4 ALFRESCO	2015
			Gen 1 - AR5 ALFRESCO	December 2016
			Gen 2 - AR5 ALFRESCO	August 2017 for Proof of Concept
Relative vegetation change (ECHAM5 and CCCMA-A1B scenario)	Spatial	Derived product depicting relative vegetation change, which is the likelihood of a pixel to transition among vegetation classes, summarized for three time periods (1900-2100, 1900-1999, and 2000-2099).	Gen 1 - AR4 ALFRESCO	2015
			Gen 1 - AR5 ALFRESCO	December 2016
			Gen 2 - AR5 ALFRESCO	August 2017 for Proof of Concept
Growth dynamics of vegetation (ECHAM5 and CCCMA-A1B scenario)	Spatial Tables Graphs	Maps and graphs showing changes in biomass over time of different plant functional types within six vegetation types (white spruce, black spruce, deciduous forest, graminoid tundra, shrub tundra, wetland tundra).	Gen 1 - AR4 DOS-TEM	2015
			Gen 1 - AR5 DVM-DOS-TEM	May 2017
			Gen 2 - AR5 DVM-DOS-TEM	August 2017 for Proof of Concept
Tanana Flats vegetation map	Spatial	Model input landcover for the Alaska Thermokarst Model (ATM) domain. The developed product is derived from both Landsat 7 ETM+ and JERS1 satellite imagery, at 30 m resolution.		2015
Barrow Peninsula geomorphology map	Spatial	Model input landcover for ATM and DVM-DOS-TEM domains. The developed product was derived from the following data products: Landsat-7 ETM+, Quickbird, and IFSAR/LIDAR Digital Elevation Models. Map resolution is at 30 m.		2015
Yukon Flats vegetation map	Spatial	Model input landcover for the ATM domain. The developed product is modified from the National Land Cover Database 2001 for Alaska, at 30 m resolution.		2016
Arctic Coastal Plain Landcover map	Spatial	Model input landcover for ATM and DVM-DOS-TEM domains. The developed product was derived from the following data products: Landsat-7 ETM+, Quickbird, and IFSAR/LIDAR Digital Elevation Models. Map resolution is at 30 m.		February 2017

Soil Properties Products (e.g., permafrost, active layer, soil temperature)

Dataset Name	Data Type	Description	Generation Model Output	Availability
Modeled soil characteristics used to drive GIPL (ECHAM5 and CCCMA-A1B scenario)	Spatial Tables Graphs	Modeled soil-related output data , such as soil moisture and organic horizon thickness.	Gen 1 - AR4 DOS-TEM	2015
			Gen 1 - AR5 DVM-DOS-TEM	May 2017
			Gen 2 - AR5 DVM-DOS-TEM	August 2017 for Proof of Concept
Permafrost distribution Active layer thickness Mean annual ground temperature (ECHAM5 and CCCMA-A1B scenario)	Spatial Tables Graphs	Maps and graphs depicting modeled permafrost distribution, simulated active layer thickness (m), and simulated mean annual ground temperature (°C).	Gen 1 - AR4 GIPL	2016
			Gen 1 - AR5 GIPL	February 2017
			Gen 2 - AR5 GIPL	August 2017 for Proof of Concept

Model Code and Documentation Products

Dataset Name	Data Type	Description	Generation Model Output	Availability
IEM program code	Source Code	IEM model code and installable Linux packages will be available through http://github.com.	Gen 1	December 2016
			Gen 2	August 2017 for Proof of Concept
ATM program code for the Arctic Coastal Plain	Source Code	ATM source code used for the Barrow Peninsula application will be available through http://github.com.		April 2017
ATM program code for the Tanana Flats	Source Code	ATM source code used for the Barrow Peninsula application will be available through http://github.com.		April 2017
ATM program code for the Yukon Flats	Source Code	ATM source code used for the Barrow Peninsula application will be available through http://github.com.		April 2017

4.2. PUBLICATIONS

Year	Publication Information
2011	Barrett, K., A.D. McGuire, E.E. Hoy, and E.S. Kasischke. 2011. Potential shifts in dominant forest cover in interior Alaska driven by variations in fire severity. Ecological Applications 21:2380-2396.
2011	Callaghan, T.V., M. Johansson, O. Anisimov, H.H. Christiansen, A. Instanes, V. Romanovsky, S. Smith, and contributing authors (including A.D. McGuire). 2011. Changing permafrost and its impacts. Chapter 5 in Snow, Water, Ice, and Permafrost in the Arctic (SWIPA): Climate Change in the Cryosphere. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway, pp. 5-1 – 5-62.
2011	Grosse, G., J. Harden, M. Turetsky, A.D. McGuire, P. Camill, C. Tarnocai, S. Frolking, E.A.G. Schuur, T. Jorgenson, S. Marchenko, V. Romanovsky, K.P. Wickland, N. French, M. Waldrop, L. Bourgeau-Chavez, and R.G. Streigl. 2011. Vulnerability of high-latitude soil organic carbon in North America to disturbance. Journal of Geophysical Research – Biogeosciences, 116, G00K06, 23 pages, doi:10.1029/2010JG001507.
2011	Hayes, D.J., A.D. McGuire, D.W. Kicklighter, K.R. Gurney, T.J. Burnside, and J.M. Melillo. 2011. Is the northern high latitude land-based CO_2 sink weakening? Global Biogeochemical Cycles, 25, GB3018, 14 pages, doi:10.1029/2010GB003813.
2011	Johnson, K.D., J. Harden, A.D. McGuire, N.B. Bliss, J.G. Bockheim, M. Clark, T. Nettleton-Hollingsworth, M.T. Jorgenson, E.S. Kane, M. Mack, J. O'Donnell, C.-Lu Ping, E.A.G. Schuur, M.R. Turetsky, and D.W. Valentine. 2011. Soil carbon distribution in Alaska in relation to soil-forming factors. Geoderma 167-168:71-84.
2011	Liu, S., B. Bond-Lamberty, J.A. Hicke, R. Vargass, S. Zhao, J. Chen, S.L. Edburg, Y. Hu, J. Liu, A.D. McGuire, J. Xiao, R. Keane, W. Yuan, J. Tang, Y. Luo, C. Potter, and J. Oeding. 2011. Simulating the impacts of disturbances on forest carbon cycling in North America: Processes, data, models, and challenges. Journal of Geophysical Research – Biogeosciences, 116, G00K08, 22 pages, doi:10.1029/2010JG001585.
2011	Magness, D.R., J.M. Morton, F. Huettmann, F.S. Chapin III, and A.D. McGuire.2011. A climate-change adaptation framework to reduce continental-scale vulnerability across conservation reserves. Ecosphere 2, Article 112, 23 pages, doi:10.1890/ES11-00200.1.
2011	O'Donnell, J.A., J.W. Harden, A.D. McGuire, and V.E. Romanovsky. 2011. Exploring the sensitivity of soil carbon dynamics to climate change, fire disturbance and permafrost thaw in a black spruce ecosystem. Biogeosciences 8:1367-1382, doi:10.5194/bg-8-1367-2011.
2011	O'Donnell, J.A., J.W. Harden, A.D. McGuire, M.Z. Kanevskiy, M.T. Jorgenson, and X. Xu. 2011. The effect of fire and permafrost interactions on soil carbon accumulation in an upland black spruce ecosystem of interior Alaska: Implications for post-thaw carbon loss. Global Change Biology 17:1461-1474, doi:10.1111/j.1365-2486.2010.02358.x.
2011	Pan, Y., R.A. Birdsey, J. Fang, R. Houghton, P.E. Kauppi, W.A. Kurz, O.L. Phillips, A. Shvidenko, S.L. Lewis, J.G. Canadell, P. Ciais, R.B. Jackson, S. Pacala, A.D. McGuire, S. Piao, A. Rautiainen, S. Sitch, and D. Hayes. 2011. A large and persistent carbon sink in the world's forests. Science 333:988-993, doi:10.1126/science.1201609.
2012	Boike, J., M. Langer, H. Lantuit, S. Muster, K. Roth, T. Sachs, P. Overduin, S. Westermann, and A.D. McGuire. 2012. Permafrost - physical aspects, carbon cycling, databases and uncertainties. Chapter 8 in Recarbonization of the Biosphere – Ecosystems and the Global Carbon Cycle (edited by R. Lal, K. Lorenz, R.F. Hüttl, B.U. Schneider, and J. von Braun). Springer, Dordrecht, The Netherlands, pp. 159-186, doi 10.1007/978-94-007-4159-1.
2012	Harden, J.W., C.D. Koven, C.-Lu Ping, G. Hugelius, A.D. McGuire, P. Camill, T. Jorgenson, P. Kuhry, G.J. Michaelson, J.A. O'Donnell, E.A.G. Schuur, C. Tarnocai, K. Johnson, and G. Grosse. 2012. Field information links permafrost carbon to physical vulnerabilities of thawing. Geophysical Research Letters 39, L15704, 6 pages, doi:10.1029/2012GL051958.
2012	Hayes, D.J., D.P. Turner, G. Stinson, A.D. McGuire Y. Wei, T.O. West, L.S. Heath, B. deJong, B. McConkey, R. Birdsey, W.A. Kurz, A. Jacobson, D.N. Huntzinger, Y. Pan, W.M. Post, and R.B. Cook. 2012. Reconciling estimates of the contemporary North American carbon balance among terrestrial biosphere models, atmospheric inversions and a new approach for estimating net ecosystem exchange from inventory-based data. Global Change Biology 18:1282-1299. doi: 10.1111/j.1365-2486.2011.02627.x.
2012	Huntzinger, D.N., W.M. Post, Y. Wei, A.M. Michalak, T.O. West, A.R. Jacobson, I.T. Baker, J.M. Chen, K.J. Davis, D.J. Hayes, F.M. Hoffman, A.K. Jain, S. Liu, A.D. McGuire, R.P. Neilson, C. Potter, B. Poulter, D. Price. B.M. Raczka, H.Q. Tian, P. Thornton, E. Tomelleri, N. Viovy, J. Xiao, W. Yuan, N. Zeng, M. Zhao, and R. Cook. 2012. North American Carbon Project (NACP) regional interim synthesis: Terrestrial biospheric model intercomparison. Ecological Modeling 232:144-157.
2012	Joly, K., P.A. Duffy, and T.S. Rupp 2012. Simulating the effects of climate change on fire regimes in Arctic biomes: implications for caribou and moose habitat. Ecosphere. 3(5). 1-18.
2012	Mann, D.H., T.S. Rupp, M. Olson, and P. Duffy 2012. Is Alaska's Boreal Forest Now Crossing a Major Ecological Threshold. Arctic, Antarctic and Alpine Research. 44(3): 319-331. doi: http://dx.doi.org/10.1657/1938-4246-44.3.319
2012	Markon, C.J., S.F. Trainor, F.S. Chapin., III (editors) and contributors (including A.D. McGuire). 2012. The United States National Climate Assessment – Alaska Technical Regional Report. U.S. Geological Survey Circular 1379, 148 p.

2012	McGuire, A.D., T. Christensen, D. Hayes, A. Heroult, E. Euskirchen, J.S. Kimball, C. Koven, P. Lefleur, P. Miller, P. Peylin, W. Oechel, M. Williams, and Y. Yi. 2012. An assessment of the carbon balance of arctic tundra: Comparisons among observations, process models, and atmospheric inversions. Biogeosciences 9: 3185-3204, doi:10.5194/bg-9-3185-2012.
2012	Muskett, R. 2012. Multi-Satellite and Sensor Derived Trends and Variation of Snow Water Equivalent on the High-Latitudes of the Northern Hemisphere. International Journal of Geosciences. 3(1). 1-13. doi: 10.4236/ijg.2012.31001.
2012	Muskett, R. 2012. Remote Sensing, Model-Derived and Ground Measurements of Snow Water Equivalent and Snow Density in Alaska. International Journal of Geosciences. 3(5). 1127-1136. doi: 10.4236/ijg.2012.35114.
2012	O'Donnell, J.A., M.T. Jorgenson, J.W. Harden, A.D. McGuire, M.Z. Kanevskiy, and K.P. Wickland. 2012. The effects of permafrost thaw on soil hydrologic, thermal and carbon dynamics in an Alaskan peatland. Ecosystems 15:213-229. doi:10.1007/s10021-011-9504-0.
2012	Rocha, A.V., M. M. Loranty, P. E. Higuera, M. C. Mack, F. Sheng-Hu, B. M. Jones, A. L. Breen, E. B. Rastetter, S. J. Goetz & G. R. Shaver. 2012. The footprint of Alaskan tundra fires during the past half-century: implications for surface properties and radiative forcing. Environmental Research Letters. 7: 1-9. doi:10.1088/1748-9326/7/4/044039
2012	Turetsky, M.R., B. Bond-Lamberty, E. Euskirchen, J. Talbot, S. Frolking, A.D. McGuire, and E.-S. Tuittila. 2012. The resilience and functional role of moss in boreal and arctic ecosystems. Tansley Review. New Phytologist 196:49-67, doi:10.1111/j.1469-8137.2012.04254.x.
2012	Waldrop, M.P., J.W. Harden, M.R. Turetsky, D.G. Petersen, A.D. McGuire, M.J.I. Briones, A.C. Churchill, D.H. Doctor, and L.E. Pruett. 2012. Bacterial and enchytraid abundance accelerate soil carbon turnover along a lowland vegetation gradient in Alaska. Soil Biology & Biochemistry 50:188-198, doi:10.1016/j.soilbio.2012.02.032.
2012	Weng, E., Y. Luo, W. Wang, H. Wang, D.J. Hayes, A.D. McGuire, A. Hastings, and D.S. Schimel. 2012. Ecosytem carbon storage capacity as affected by disturbance regimes: A general theoretical model. Journal of Geophysical Research – Biogeosciences 117, G03014, 15 pages, doi:10.1029/2012JG002040.
2012	Williams, B.K., Wingard, G.L., Brewer, Gary, Cloern, James, Gelfenbaum, Guy, Jacobson, R.B., Kershner, J.L., McGuire, A.D., Nichols, J.D., Shapiro, C.D., van Riper III, Charles, and White, R.P. 2012. The U.S. Geological Survey Ecosystem Science Strategy, 2012–2022—Advancing discovery and application through collaboration: U.S. Geological Survey Open-File Report 2012–1092, 29 p.
2012	Wolken, J.M., T.N. Hollingsworth, T.S. Rupp, F.S. Chapin III, S.F. Trainor, T.M. Barrett, P.F. Sullivan, A.D. McGuire, E.S. Euskirchen, P.E. Hennon, E.A. Beever, J.S. Conn, L.K. Crone, D.V. D'Amore, N. Fresco, T.A. Hanley, K. Kielland, J.J. Kruse, T. Patterson, E.A.G. Schuur, D.L. Verbyla, and J. Yarie 2012. Evidence and implications of recent and projected climate change in Alaska's forest ecosystems. Ecosphere.
2012	Yuan, F. –M, S.-H. Yi, A. D. McGuire, K. D. Johnson, J.-J. Liang, J. W. Harden, E. Kasischke, and W.A. Kurz. 2012. Assessment of historical boreal forest carbon dynamics in the Yukon River Basin: Relative roles of climate warming and fire regime changes. Ecological Applications 22:2091-2109.
2013	Bali, A.V. Alexeev, R.G. White, D.E. Russell, A.D. McGuire and G.P. Kofinas. 2013. Long-term patterns of abiotic drivers of mosquito activity within summer ranges of Northern Alaska caribou herds (1979–2009). Rangifer 33, Special Issue No. 21: 173-176.
2013	Fan, Z., A.D. McGuire, M.R. Turetsky, J.W. Harden, J.M. Waddington, and E.S. Kane 2013. The response of soil organic carbon of a rich fen peatland in interior Alaska to projected climate change . Global Change Biology. 19. 604-620. doi:10.1111/gcb.12041#sthash.YblhM3gR.dpuf.
2013	Genet H., A. D. McGuire, K. Barrett, A. L. Breen, E. S. Euskirchen, J. F. Johnstone, E. S. Kasischke, A. M. Melvin, A. Bennet, M. C. Mack, T. S. Rupp, A. E. G. Schuur, M. R. Turetsky & F. Yuan. 2013. Modeling the effects of fire severity and climate warming on active layer depth and soil carbon dynamics of black spruce forests across the landscape in Interior Alaska . Environmental Research Letters. 8(4). 1-13. doi:10.1088/1748-9326/8/4/045016#sthash.oKj4WKIL.dpuf.
2013	He, Y., Q. Zhuang, A.D. McGuire, Y. Liu, and M. Chen 2013. Alternative ways of using field-based estimates to calibrate ecosystem models and their implications for ecosystem carbon cycle studies . Journal of Geophysical Research: Biogeosciences. 118. 1-11. doi:10.1002/jgrg.20080.
2013	Hinzman, L.D., C. Deal, A.D. McGuire, I Polyakov, J. Walsh, and S.H. Mernild. 2013. Trajectory of the Arctic as an integrated system. Ecological Applications 23:1837-1868.
2013	Jafarov, E.E., V.E. Romanovsky, H. Genet, A.D. McGuire, and S.S. Marchenko 2013. The effects of fire on the thermal stability of permafrost in lowland and uplandblack spruce forests of interior Alaska in a changing climate . Environmental Research Letters. 8(3). doi:10.1088/1748-9326/8/3/035030.
2013	Johnson, K.D., J.W. Harden, A.D. McGuire, M. Clark, F.M. Yuan, and A. Finley 2013. Permafrost and organic layer interactions over a climate gradient in a discontinuous permafrost zone. Environmental Research Letters. 8(3). doi:10.1088/1748-9326/8/3/035028#sthash.gerrtuej.dpuf.
2013	Jones, B. M., A. L. Breen, B. V. Gaglioti, D. H. Mann, Adrian V. Rocha, G. Grosse, C. D. Arp & D. A. Walker 2013. Identification of unrecognized tundra fire events on the North Slope of Alaska . Journal of Geophysical Research. 118(3). 1334-1344. doi:10.1002/jgrg.20113.
2013	Kane, E.S., M.R. Chivers, M.R. Turetsky, C.C. Treat, D.G. Petersen, M. Waldrop, J.W. Harden, and A.D. McGuire 2013. Response of anaerobic carbon cycling to water table manipulation in an Alaskan rich fen . Soil Biology and Biogeochemistry. 58. 50-60. doi:10.1016/j.soilbio.2012.10.032.
2013	Kicklighter, D.W., D.J. Hayes, J.W. McClelland, B.J. Peterson, A.D. McGuire, and J.M. Melillo. 2013. Insights and issues with simulating terrestrial DOC loading of arctic river networks. Ecological Applications 23:1817-1836.
2013	McConnell, N.A, M.R. Turetsky, A.D. McGuire, E.S. Kane, M.P. Waldrop, and J.W. Harden 2013. Controls on ecosystem and root respiration across a permafrost and wetland gradient in interior Alaska . Environmental Research Letters. 8(4). doi:10.1088/1748-9326/8/4/045029#sthash.VAsQ924a.dpuf.

2013	McGuire, A.D. 2013. Ecosystem Element Cycling. In: Encyclopedia of Environmetrics 2nd Edition (eds. El-Shaarawi A.H., Piegorsch W.W.). John Wiley & Sons Ltd, Chichester, UK, pp. 779-783. Doi 10.1002/9780470057339.vae011.pub2.
2013	McGuire, A.D., L.D. Hinzman, J. Walsh, J. Hobbie, and M. Sturm. 2013. Introduction for invited feature "Trajectory of the Arctic as an Integrated System". Ecological Applications 23:1743-1744.
2013	Mishra, U., J.D. Jastrow, R. Matamala, G. Hugelius, C.D. Koven, J.W. Harden, C.L. Ping, G.J. Michaelson, Z. Fan, R.M. Miller, A.D. McGuire, C. Tarnocai, P. Kuhry, W.J. Riley, K. Schaefer, E.A.G. Schuur, M.T. Jorgenson, and L.D. Hinzman 2013. Empirical estimates to reduce modeling uncertainties of soil organic carbon in permafrost regions: A review of recent progress and remaining challenges . Environmental Research Letters. 8(3). doi:10.1088/1748-9326/8/3/035020#sthash.DmOPqxmG.dpuf.
2013	Muskett, R. 2013. GOSAT CH_4 and CO_2, MODIS Evapotranspiration on the Northern Hemisphere June and July 2009, 2010 and 2011. Atmospheric and Climate Sciences. 3(2). 177-185. doi: 10.4236/acs.2013.32019.
2013	Muskett, R. 2013. MODIS-Derived Arctic Land-Surface Temperature Trends. Atmospheric and Climate Sciences. 3. 55-60. doi: 10.4236/acs.2013.31008.
2013	Olefeldt, D., M.R. Turetsky, P.M. Crill, and A.D. McGuire 2013. Environmental and physical controls on northern terrestrial methane emissions across permafrost zones. Global Change Biology. 19(2). 589-603. doi:10.1111/gcb.12071#sthash.dhQve4KV.dpuf.
2013	Parmentier, F.-J.W., T.R. Christensen, L.L. Sorensen, S. Rysgaard, A.D. McGuire, P.A. Miller, and D.A. Walker. 2013. The impact of lower sea ice extent on arctic greenhouse gas exchange. Nature Climate Change 3:195-202. doi:10.1038/nclimate1784.
2013	Schuur, E.A.G., B.W. Abbott, W.B. Bowden, V. Brovkin, P. Camill, J.P. Canadell, J.P. Chanton, F.S. Chapin III, T.R. Christensen, P. Ciais, P.M. Crill, B.T. Crosby, C.I. Czimczik, G. Grosse, J. Harden, D.J. Hayes, G. Hugelius, J.D. Jastrow, J.B. Jones, T. Kleinin, C.D. Koven, G. Krinner, P. Kuhry, D.M. Lawrence, A.D. McGuire, S.M. Natali, J.A. O'Donnell, C.L. Ping, W.J. Riley, A. Rinke, V.E. Romanovsky, A.B.K. Sannel, C. Schadel, K. Schaefer, J. Sky, Z.M. Subin, C. Tarnocai, M. Turetsky, M. Waldrop, K.M. Walter-Anthony, K.P. Wickland, C.J. Wilson, and S.A. Zimov. 2013. Expert assessment of potential permafrost carbon feedback to climate change. Climatic Change 119:359-374. doi:10.1007/s10584-013-0730-7.
2013	Ueyama, M., K. Ichii, H. Iwata, E.S. Euskirchen, D. Zona, A.V. Rocha, Y. Harazono, C. Iwama, T. Nakai, W.C. Oechel. 2013. Upscaling terrestrial carbon dioxide fluxes in Alaska with satellite remote sensing and support vector regression. Journal of Geophysical Research – Biogeosciences.
2013	Ueyama, M., K. Ichii, H. Iwata, E.S. Euskirchen, D. Zona, A.V. Rocha, Y. Harazono, C. Iwama, T. Nakai, W.C. Oechel. 2013. Upscaling terrestrial carbon dioxide fluxes in Alaska with satellite remote sensing and support vector regression. Journal of Geophysical Research – Biogeosciences.
2013	Williams, B.K., Wingard, G.L., Brewer, Gary, Cloern, J.E., Gelfenbaum, Guy, Jacobson, R.B., Kershner, J.L., McGuire, A.D., Nichols, J.D., Shapiro, C.D., van Riper III, Charles, and White, R.P.. 2013. U.S. Geological Survey Ecosystems Science Strategy—Advancing discovery and application through collaboration: U.S. Geological Survey Circular 1383–C, 43 p.
2013	Xu, L., R. B. Myneni, F. S. Chapin III, T.V. Callaghan, J. E. Pinzon, C. J. Tucker, B.T. Anderson, H. Tømmervik, E. S. Euskirchen, S. Piao, P. Ciais, S. Ganguly, R. R. Nemani, C. Cao, J. C. Stroeve, B. C. Forbes 2013. Diminishing Seasonality Over Northerly Lands. Nature Climate Change . Nature Climate Change. 3. 581-586. doi:10.1038/nclimate1836 #sthash.UrfEudbP.dpuf.
2013	Xu, L., R. B. Myneni, F. S. Chapin III, T.V. Callaghan, J. E. Pinzon, C. J. Tucker, B.T. Anderson, H. Tømmervik, E. S. Euskirchen,S. Piao, P. Ciais, S. Ganguly, R. R. Nemani, C. Cao, J. C. Stroeve, B. C. Forbes. 2013. Diminishing Seasonality Over Northerly Lands. Nature Climate Change.
2013	Zhuang, Q., M. Chen, K. Xu, J. Tang, E. Saikawa, Y. Lu, J.M. Melillo, R.G. Prinn and A.D. McGuire. 2013. Response of global soil consumption of atmospheric methane to changes in atmospheric climate and nitrogen deposition. Global Biogeochemical Cycles 27, 14 pages, doi:10.1002/gbc.20057.
2014	Breen, A. L. 2014. Balsam poplar (Populus balsamifera L.) communities on the Arctic Slope of Alaska. Phytocoenologia. 44. 1-17. doi: 10.1127/0340-269X/2014/0044-0522.
2014	Chapin, F.S., III, S.F. Trainor, P. Cochran, H. Huntington, C. Markon, M. McCammon, A.D. McGuire, and M. Serreze. 2014. Chapter 22: Alaska. Climate Change Impacts in the United States: The Third National Climate Assessment. J.M. Melillo, T.C. Richmond, and G.W. Yohe (editors), U.S. Global Change Research Program, pp. 514-536. doi:10.7930/J00Z7150.
2014	Euskirchen, E. S., C. W. Edgar, M. R. Turetsky, M. P. Waldrop, and J. W. Harden 2014. Differential response of carbon fluxes to climate in three peatland ecosystems that vary in the presence and stability of permafrost. Journal of Geophysical Research: Biogeosciences. 119(8). 1576–1595. DOI: 10.1002/2014JG002683
2014	Euskirchen, E.S., T.B. Carman, and A.D. McGuire. 2014. Changes in the structure and function of northern Alaskan ecosystems when considering variable leaf-out times across groupings of species in a dynamic vegetation model. Global Change Biology 20:963-978, doi: 10.1111/gcb.12392.
2014	Hayes, D.J., D.W. Kicklighter, A.D. McGuire, M. Chen, Q. Zhuang, F. Yuan, J.M. Melillo, and S.D. Wullschleger. 2014. The impacts of recent permafrost thaw on land-atmosphere greenhouse gas exchange. Environmental Research Letters 9, 12 pages, doi:10.1088/1748-9326/9/4/045005.
2014	He, Y., Q. Zhuang, J.W. Harden, A.D. McGuire, Z. Fan, Y. Liu, and K. Wickland. 2014. The implications of microbial and substrate limitation for the fates of carbon in different organic soil horizon types of boreal forest ecosystems: A mechanistically based model analysis. Biogeosciences 11:4477-4491, doi:10.5194/bg-11-4477-2014.
2014	He., Y., J. Yang,. Q. Zhuang, A.D. McGuire, Q. Zhu, Y. Liu, and R.O. Teskey. 2014. Uncertainty in the fate of soil organic carbon: A comparison of three conceptually different decomposition models at a larch plantation. Journal of Geophysical Research – Biogeosciences 119:1892-1905. doi:10.1002/2014JG002701.

2014	Iversen, C.M., V.L. Sloan, P.F. Sullivan, E.S. Euskirchen, A.D. McGuire, R.J. Norby, A.P. Walker, J.M. Warren, and S.D. Wullschleger. 2014. The unseen iceberg: Plant roots in arctic tundra. Tansley Review. New Phytologist 205:34-58. doi:10.1111/nph.13003.
2014	Jafarov, E.E., D.J. Nicolsky, V.E. Romanovsky, J.E. Walsh, S.K. Panda, and M.C. Serreze 2014. The effect of snow: How to better model ground surface temperatures. Cold Regions Science and Technology. 102. 63-77. doi:10.1016/j.coldregions.2014.02.007.
2014	Klapstein, S.J., M.R. Turetsky, A.D. McGuire, J.W. Harden, C.I. Czimczik, X. Xu, J.P. Chanton, and J.M. Waddington. 2014. Controls on the methane released through ebullition affected by permafrost degradation. Journal of Geophysical Research – Biogeosciences 119:418-431, doi:10.1002/2013JG002441.
2014	Muskett, R. 2014. Arctic Diurnal Land-Surface Temperature Range Changes Derived by NASA MODIS-Terra and -Aqua 2000 through 2012. Atmospheric and Climate Sciences. 4. 231-240. doi: 10.4236/acs.2014.42026.
2014	Muskett, R. 2014. ICESat-Derived Elevation Changes on the Lena Delta and Laptev Sea, Siberia. Open Journal of Modern Hydrology. 4(1). 1-9. doi: 10.4236/ojmh.2014.41001.
2014	Muskett, R. 2014. MODIS-Derived Nighttime Arctic Land-Surface Temperature Nascent Trends and Non-Stationary Changes. American Journal of Climate Change. 3. 169-177. doi: 10.4236/ajcc.2014.32016.
2014	Ueyama M., K. Ichii, H. Iwata, E.S. Euskirchen, D. Zona, A.V. Rocha, Y. Harazono, C. Iwama, T. Nakai, W.C. Oechel. 2014. Change in surface energy balance in Alaska due to fire and spring warming based on upscaling eddy covariance measurements. Journal of Geophysical Research Biogeosciences. doi/10.1002/2014JG002717/
2014	van Riper, C., III, J.D. Nichols, G.L. Wingard, J.L. Kershner, J. Cloern, R.B. Jacobson, R.P. White, A.D. McGuire, B.K. Williams, G. Gelfenbaum, and C.D. Shapiro. 2014. USGS ecosystem research for the next decade: Advancing discovery and application in parks and protected areas through collaboration. George Wright Forum 31:129-136.
2014	Wullshleger, S., H.E. Epstein, E.O. Box, E.S. Euskirchen, S. Goswami, C.M. Iverson, J. Kattage, R. Norby, P.M. van Bodegom, X. Xu. 2014. Plant functional types in Earth System Models: Past experiences and future directions for application of dynamic vegetation models in high-latitude ecosystems. Invited Review, Journal of Botany 114: 1-16.
2015	Biskaborn, B. K., J-P. Lanckman, H. Lantuit, K. Elger, D. A. Streletskiy, W. L. Cable, and V. E. Romanovsky 2015. The Global Terrestrial Network for Permafrost database: Metadata statistics and prospective analysis on future permafrost temperature and active layer depth monitoring site distribution. Earth System Science Data. 8. 279-315. doi: 10.5194/essdd-8-279-2015.
2015	Brown, C.B., K. Seaton, T. Brinkman, E.S. Euskirchen, K. Kielland. 2015. Incorporating resilience thinking into management of a moose-hunter system in Alaska. Ecology and Society, Special Issue on 'Northern Socio-ecological Systems'
2015	Brown, D. R.N., M.T. Jorgenson, T. A. Douglas, V. E. Romanovsky, K. Kielland, C. Hiemstra, E. S. Euskirchen, and R. W. Ruess 2015. Interactions of fire and climate exacerbate permafrost degradation in Alaskan lowland forests. Journal of Geophysical Research: Biogeosciences. 120(8). doi: 10.1002/2015JG003033.
2015	Brown, D.R.N., M.T. Jorgenson, T.A. Douglas, V.E. Romanovsky, K. Kiellland, C. Hiemstra, E.S. Euskirchen, R.W. Ruess. 2015. Interactions of fire and climate increase permafrost thaw in Alaskan lowland forest. Journal of Geophysical Research – Biogeosciences.
2015	Calef, M.P., A. Varvak, A.D. McGuire, F.S. Chapin III, and K.B. Reinhold 2015. Recent changes in annual area burned in interior Alaska: The impact of fire management. Earth Interactions. 19. 1-17. doi: 10.1175/EI-D-14-0025.1.
2015	Churchill, A.C., M.R. Turetsky, A.D. McGuire, and T.N. Hollingsworth 2015. Response of plant community structure and primary productivity to experimental drought and flooding in an Alaskan fen. Canadian Journal of Forest Research. 45. 185-193. doi: 10.1139/cjfr-2014-0100.
2015	Hewitt, R. E., A. P. Bennett, A. L. Breen, T. N. Hollingsworth, D. L. Taylor, F. S. Chapin III, and T. S. Rupp. 2015. Getting to the root of the matter: Landscape implications of plant-fungal interactions for tree migration in Alaska. Landscape Ecology . 1-17. doi: 10.1007/s10980-015-0306-1.
2015	Hultman, J., M.P. Waldrop, R. Mackelprang, M.M. David, J. McFarland, S.J. Blazewicz, J. Harden, M.R. Turetsky, A.D. McGuire, M.B. Shah, N.C. VerBerkmoes, L.H. Lee, K. Mavrommatis, and J.K. Jansson 2015. Multi-omics of permafrost, active layer and thermokarst bog soil microbiomes. Nature. 521. 208-212. doi: 10.1038/nature14238.
2015	King, A.W., R.J. Andres, K.J. Davis, M. Hafer, D.J. Hayes, D.N. Huntzinger, B. de Jong, W.A. Kurz, A.D. McGuire, R. Vargas, Y. Wei, T.O. West, and C.W. Woodall 2015. North America's net terrestrial CO_2 exchange with the atmosphere 1990-2009. . Biogeosciences. 12. 399-414. doi: 10.5194/bg-12-399-2015.
2015	Koven, C.D., E.A.G. Schuur, C. Schadel, T.J. Bohn, E.J. Burke, G. Chen, X. Chen, P. Ciais, G. Grosse, J.W. Harden, D.J. Hayes, G. Hugelius, E.E. Jafarov, G. Krinner, P. Kuhry, D.M. Lawrence, A.H. MacDougall, S.S. Marchenko, A.D. McGuire, S.M. Natali, D.J. Nicolsky, D. Olefeldt, S. Peng, V.E. Romanovsky, K.M. Schaefer, J. Strauss, C.C. Treat, and M. Turetsky 2015. A simplified, data-constrained approach to estimate the permafrost carbon–climate feedback. Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences . 373(2054). doi: 10.1098/rsta.2014.0423.
2015	Lara, M. J., A. D. McGuire, E. S. Euskirchen, C.E. Tweedie, K. M. Hinkel, A. N. Skurikhin, V. E. Romanovsky, G. Grosse, W. R. Bolton, and H. Genet 2015. Polygonal tundra geomorphological change in response to warming alters future CO_2 and CH_4 flux on the Barrow Peninsula. Global Change Biology. 21(4). 1634-1651. doi: 10.1111/gcb.12757.
2015	Lara, M. J., H. Genet, A. D. McGuire, E. S. Euskirchen, Y. Zhang, D. Brown, M.T. Jorgenson, V. Romanovsky, A. L. Breen, and R. W. Bolton 2015In Press. Thermokarst rates intensify due to climate change and forest fragmentation in an Alaskan boreal forest lowland. Global Change Biology. doi: 10.1111/gcb.13124.
2015	Liang, J., M. Zhou, P.C. Tobin, A.D. McGuire, and P.B. Reich 2015. Biodiversity influences plant productivity through niche-efficiency. Proceedings of the National Academy of Sciences . 112(18). 5738-5743. doi: 10.1073/pnas.1409853112.

2015	Melvin, A.M., M.C. Mack, J.F. Johnstone, A.D. McGuire, H. Genet, and E.A.G. Schuur. 2015. Differences in ecosystem carbon distribution and nutrient cycling linked to forest tree species composition in a mid-successional boreal forest. Ecosystems 18:1472-1488, doi:10.1007/s10021-015-9912-7.
2015	Muskett R. R., V. E. Romanovsky, W. L. Cable, and A. L. Kholodov 2015. Active-Layer Soil Moisture Content Regional Variations in Alaska and Russia by Ground-Based and Satellite-Based Methods, 2002 Through 2014. International Journal of Geoscience. 6. 12-41. doi: 10.4236/ijg.2015.61002 .
2015	Muskett, R. , V. Romanovsky, W. Cable, and A. Kholodov 2015. Active-Layer Soil Moisture Content Regional Variations in Alaska and Russia by Ground-Based and Satellite-Based Methods, 2002 through 2014. International Journal of Geosciences. 6(1). 12-41. doi: 10.4236/ijg.2015.61002.
2015	Muskett, R. 2015. ICESat GLAS Elevation Changes and ALOS PALSAR InSAR Line-of-Sight Changes on the Continuous Permafrost Zone of the North Slope, Alaska. International Journal of Geosciences. 6. 1101-1115. doi: 10.4236/ijg.2015.610086.
2015	Noetzli, J., H. H. Christiansen, V. E. Romanovsky, N. I. Shiklomanov, S. L. Smith, G. Vieira and L. Zhao 2015. [Global Climate] Cryosphere, Permafrost thermal state [in "State of the Climate in 2014"]. Bulletin of the American Meteorological Society. 96 (7). S17-S18.
2015	Parmentier, F.J.W., W. Zhang, Y. Mi, X. Zhu, J. van Huissteden, D.J. Hayes, Q. Zhuang, T.R. Christensen, and A.D. McGuire 2015. Rising methane emissions from northern wetlands associated with sea ice decline. Geophysical Research Letters. 42(17). 7214-7222. doi: 10.1002/2015GL065013.
2015	Rawlins, M., A.D. McGuire, J.S. Kimball, P. Dass, D. Lawrence, E. Burke, X. Chen, C. Delire, C. Koven, A. MacDougall, S. Peng, A. Rinke, K. Saito, W. Zhang, R. Alkama, T.J. Bohn, P. Ciais, B. Decharme, I. Gouttevin, T. Hajima, D. Ji, G. Krinner, D.P. Lettenmaier, P. Miller, J.C. Moore, B. Smith, and T. Sueyoshi 2015. Assessment of model estimates of land-atmosphere CO_2 exchange across northern Eurasia. Biogeosciences. 12(14). 4385-4405. doi: 10.5194/bg-12-4385-2015.
2015	Romanovsky, V. E., S. L. Smith, H. H. Christiansen, N. I. Shiklomanov, D. A. Streletskiy, D. S. Drozdov, G. V. Malkova, N. G. Oberman, A. L. Kholodov, and S. S. Marchenko 2015. [The Arctic] Terrestrial Permafrost [in "State of the Climate in 2014"]. Bulletin of the American Meteorological Society. 96(7). S139-S141.
2015	Schuur, E. A. G., A. D. McGuire, C. Schädel, G. Grosse, J. W. Harden, D. J. Hayes, G. Hugelius, C. D. Koven, P. Kuhry, D. M. Lawrence, S. M. Natali, D. Olefeldt, V. E. Romanovsky, K. Schaefer, M. R. Turetsky, C. C. Treat, and J. E. Vonk 2015. Climate change and the permafrost carbon feedback. Nature. doi: 10.1038/nature14338.
2015	Treat, C.C., S.M. Natali, J. Ernakovich, C.M. Iversen, M. Lupascu, A.D. McGuire, R.J. Norby, T.R. Chowdhury, A. Richter, H. Santruckova, C. Schadel, E.A.G. Schuur, V.L. Sloan, M.R. Turetsky, and M.P. Waldrop 2015. A pan-Arctic synthesis of CH_4 and CO_2 production from anoxic soil incubations. Global Change Biology. 21(7). 2787-2803. doi: 10.1111/gcb.12875.
2015	Yi, Y., J. S. Kimball, M. A. Rawlins, M. Moghaddam, and E. S. Euskirchen 2015. The role of snow cover and soil freeze/thaw cycles on boreal-arctic soil carbon dynamics. Biogeosciences. 12. 5811-5829. doi: 10.5194/bg-12-5811-2015.
2015	Yi, Y., J.S. Kimball, M.A. Rawlins, M. Moghaddam, E.S. Euskirchen. 2015. The role of snow cover and soil freeze/thaw cycles on boreal-arctic soil carbon dynamics. Biogeosciences.
2015	Zhuang, Q., X. Zhu, Y. He, C. Prigent, J.M. Melillo, A.D. McGuire, R.G. Prinn, and D.W. Kicklighter 2015. Influence of changes in wetland inundation extent on net fluxes of carbon dioxide and methane in northern high latitudes from 1993 to 2004. Environmental Research Letters. 10. doi: 10.1088/1748-9326/10/9/095009.
2016	Abbott, B.W., J.B. Jones, E.A.G. Schuur, F.S. Chapin III, W.B. Bowden, M.S. Bret-Harte, H.E. Epstein, M.D. Flannigan, T.K. Harms, T.N. Hollingsworth, M.C. Mack, A.D. McGuire, S.M. Natali, A.V. Rocha, S.E. Tank, M.R. Turetsky, J.E. Vonk, K.P. Wickland, G.R. Aiken, H.D. Alexander, R.M.W. Amon, B.W. Benscoter, Y. Bergeron, K. Bishop, O. Blarquez, B. Bond-Lamberty, A.L. Breen, I. Buffam, Y. Cai, C. Carcaillet, S.K Carey, J.M. Chen, H.Y.H. Chen, T.R. Christensen, L.W. Cooper, J.H.C. Cornelissen, W.J. de Groot, T.H. DeLuca, E. Dorrepaal, N. Fetcher, J.C. Finlay, B.C. Forbes, N.H. French, S. Gauthier, M.P. Girardin, S.J. Goetz, J.G. Goldammer, L. Gough, P. Grogan, L. Guo, P.E. Higuera, L. Hinzman, F.S. Hu, G. Hugelius, E.E. Jafarov, R. Jandt, J.F. Johnstone, J. Karlsson, E.S. Kasischke, G. Kattner, R. Kelly, F. Keuper, G.W. Kling, P. Kortelainen, J. Kouki, P. Kuhry, H. Laudon, I. Laurion, R.W. Macdonald, P.J. Mann, P.J. Martikainen, J.W. McClelland, U. Molau, S.F. Oberbauer, D. Olefeldt, D. Pare, M.-A. Parisien, S. Payette, C. Peng, O.S. Pokrovsky, E.B. Rastetter, P.A. Raymond, M.K. Raynolds, G. Rein, J.F. Reynolds, M. Robards, B.M. Rogers, C. Schadel, K. Schaefer, I.K. Schmidt, A. Shvidenko, J. Sky, R.G.M. Spencer, G. Starr, R.G. Striegl, R. Teisserenc, L.J. Tranvik, T. Virtanen, J. Welker, and S. Zimov. 2016. Biomass offsets little or none of permafrost carbon release from soils, streams, and wildfire: An expert assessment. Environmental Research Letters 11, paper 034014, 13 pages, doi:10.1088/1748-9326/11/3/034014.
2016	Ackerman, D. & A. L. Breen. 2016. Infrastructure development may accelerate range expansion of trembling aspen (Populus tremuloides, Salicaceae) Arctic http://dx.doi.org/10.14430/arctic4560
2016	Bond-Lamberty, B., D. Epron, J. Harden, M.E. Harmon, F. Hoffman, J. Kumar, A.D. McGuire, and R. Vargas. 2016. Estimating heterotrophic respiration at large scales: Challenges, approaches, and next steps. Ecosphere 7, Article e01380, 13 pages, doi:e01380.10.1002/ecs2.1380.
2016	Breen, A.L., A. Bennett, T. Kurkowski, M. Lindgren, J. Schroder, A.D. McGuire, and T.S. Rupp. 2016. Projecting vegetation and wildfire response to changing climate and fire management in interior Alaska. Alaska Fire Science Consortium Research Summary 2016-1, 7 pages.
2016	Cable, W. L., V. E. Romanovsky, and M. T. Jorgenson, Scaling-up Permafrost Thermal Measurements in Western Alaska using an Ecotype Approach, The Cryosphere Discuss., doi:10.5194/tc-2016-30, 2016.
2016	Euskirchen, ES., A. Bennett, A.L. Breen, H. Genet, M. Lindgren, T. Kurkowski, A.D. Mcuire, A; T.S. Rupp. In press. Consequences of changes in vegetation and snow cover for climate feedbacks in Alaska and northwest Canada. Environmental Research Letters 11, paper 105003, 19 pages, doi:10.1088/1748-9326/11/10/105003.

2016	Finger, R.A., M.R. Turetsky, K. Kielland, R.W. Ruess, M.C. Mack, E.S. Euskirchen. 2016. Effects of permafrost thaw on nitrogen availability and plant-soil interactions in a boreal Alaskan lowland. Journal of Ecology. doi: 10.1111/1365-2745.12639
2016	Genet, H., Y. He, A.D. McGuire, Q. Zhuang, Y. Zhang, F. Biles, D.V. D'Amore, X. Zhou, and K.D. Johnson. 2016. Terrestrial carbon modeling: Baseline and projections in upland ecosystems. Chapter 6 (pages 105-132) in Z. Zhu and A.D. McGuire, eds., Baseline and projected future carbon storage and greenhouse-gas fluxes in ecosystems of Alaska. U.S. Geological Survey Professional Paper 1826, 196 p., http://dx.doi.org/10.3133/pp1826.
2016	Grosse, G., Goetz, S., McGuire, A., Romanovsky, V., and E. Schuur 2016. Review and Synthesis: Changing Permafrost in a Warming World and Feedbacks to the Earth System. Environmental Research Letters. 11(4).
2016	He, Y., H. Genet, A.D. McGuire, Q. Zhuang, B.K. Wylie, and Y. Zhang. 2016. Terrestrial carbon modeling: Baseline and projections in lowland ecosystems of Alaska. Chapter 7 (pages 133-158) in Z. Zhu and A.D. McGuire, eds., Baseline and projected future carbon storage and greenhouse-gas fluxes in ecosystems of Alaska. U.S. Geological Survey Professional Paper 1826, 196 p., http://dx.doi.org/10.3133/pp1826.
2016	He, Y., J. Yang, Q. Zhuang, J.W. Harden, A.D. McGuire, Y. Liu, G. Wang, L. Gu. 2016. Incorporating microbial dormancy dynamics into soil decomposition models to improve quantification of soil carbon dynamics of northern temperate forests. Journal of Geophysical Research - Biogeosciences 120:2596-2611, doi:10.1002/2015JG0031.30.
2016	Helbig, M., K. Wischnewski, G.H. Gosselin, S. Biraud, I. Bogoev, W.S. Chan, E.S. Euskirchen, A. Glenn, E.R. Humphreys, P.M. Marsh, W.L. Quinton, O. Sonnentag. 2016. Sensible heat bias in carbon dioxide flux measurements by an open-path eddy covariance system. Agricultural and Forest Meteorology.
2016	Jones, B.M., C.A. Baughman, V.E. Romanovsky, A.D. Parsekian, E.L. Babcock, M.C. Jones, G. Grosse, and E.E. Berg, The presence of rapidly degrading permafrost plateaus in southcentral Alaska, The Cryosphere Discuss., 2016, 1-49, doi:10.5194/tc-2016-91
2016	Kelly, R., H. Genet, A.D. McGuire, and F.S. Hu. 2016. Paleodata-informed modeling of large carbon losses from recent burning of boreal forests. Nature Climate Change 6:79-82, doi:10.1038/nclimate2832.
2016	Lara, M.J., H. Genet, A.D. McGuire, E.S. Euskirchen, Y. Zhang, D. Brown, M.T. Jorgenson, V. Romanovsky, A. Breen, W.R. Bolton. 2016. Thermokarst rates intensify due to climate change and forest fragmentation in an Alaskan boreal forest lowland. Global Change Biology. doi: 10.1111/gcb.13124.
2016	Liang, J., T.W. Crowther, N. Picard, S. Wiser, M. Zhou, G. Alberti, E.-D. Schulze, A.D. McGuire, F. Bozzato, H. Pretzsch, S. de-Miguel, A. Paquette, B. Herault, M. Scherer-Lorenzen, C.B. Barrett, H.B. Glick, G.M. Hengeveld, G.-J. Nabuurs, S. Pfautsch, H. Viana, A.C. Bibrans, C. Ammer, P. Schall, D. Verbyla, N. Tchbakova, M. Fischer, J.V. Watson, H.Y.H. Chen, X. Lei, M.-J. Schelhaas, H. Lu, D. Gianelle, E.I. Parfenova, C. Salas, E. Lee, B. Lee, H.S. Kim, H. Bruelheide, D.A. Coomes, D. Piotto, T. Sunderland, B. Schmid, S. Gourlet-Fleury, B. Sonke, R. Tavani, J. Zhu, S. Brandl, J. Vayreda, F. Kitahara, E.B. Searle, V.J. Neldner, M.R. Ngugi, C. Baraloto, L. Frizzera, R. Balazy, J. Oleksyn, T. Zawila-Niedzwiecki, O. Bouriaud, F. Bussotti, L. Finer, B. Jaroszewicz, T. Jucker, F. Valladares, A.M. Jagodzinski, P.L. Peri, C. Gonmadje, W. Marthy, T. O'Brien, E.H. Martin, A. Marshall, F. Rovero, R. Bitariho, P.A. Niklaus, P. Alvarez-Loayza, N. Chamuya, R. Valencia, F. Mortier, V. Wortel, N.L. Engone-Obiang, L.V. Ferreira, D.E. Odeke, R.M. Vasquez, and P.B. Reich. 2016. Positive biodiversity-productivity relationship predominant in global forests. Science 354:6309, 12 pages, doi:10.1126/science.aaf8957.
2016	Luo, Y., A. Ahlstrom, S.D. Allison, N.H. Batjes, V. Brovkin, N. Carvalhais, A. Chappell, P. Ciais, E.A. Davidson, A. Finzi, K. Georgiou, B. Guenet, O. Hararuk, J.W. Harden, Y. He, F. Hopkins, L. Jiang, C. Koven, R.B. Jackson, C.D. Jones, M.J. Lara, J. Liang, A.D. McGuire, W. Parton, C. Peng, J.T. Randerson, A. Salazar, C.A. Sierra, M.J. Smith, H. Tian, K.E.O. Todd-Brown, M. Torn, K.J. van Groenigen, Y.P. Wang, T.O. West, Y. Wei, W.R. Wieder, J. Xia, X. Xu, X. Xu, and T. Zhou. 2016. Toward more realistic projections of soil carbon dynamics by Earth system models. Global Biogeochemical Cycles 30:40-56, doi:10.1002/2015GB005239.
2016	McGuire, A.D., B.K. Wylie, D.V. D'Amore, X. Zhou, T.S. Rupp, H. Genet, Y. He, S. Stackpoole, and Z. Zhu. 2016. Executive Summary-Baseline and Projected Future Carbon Storage and Greenhouse-Gas Fluxes in Ecosystems of Alaska. Pages 1-3 in Z. Zhu and A.D. McGuire, eds., Baseline and projected future carbon storage and greenhouse-gas fluxes in ecosystems of Alaska. U.S. Geological Survey Professional Paper 1826, 196 p., http://dx.doi.org/10.3133/pp1826.
2016	McGuire, A.D., C. Koven, D.M. Lawrence, J.S. Clein, J. Xia, C. Beer, E. Burke, G. Chen, X. Chen, C. Delire, E. Jafarov, A.H. MacDougall, S. Marchenko, D. Nicolsky, S. Peng, A. Rinke, K. Saito, W. Zhang, R. Alkama, T.J. Bohn, P. Ciais, B. Decharme, A. Ekici, I. Gouttevin, T. Hajima, D.J. Hayes, D. Ji, G. Krinner, D.P. Lettenmaier, P.A. Miller, J.C. Moore, V. Romanovsky, C. Schadel, K. Schaefer, E.A.G. Schuur, B. Smith, T. Sueyoshi, and Q. Zhuang. 2016. Variability in the sensitivity among model simulations of permafrost and carbon dynamics in the permafrost region between 1960 and 2009. Global Biogeochemical Cycles 30:1015-1037, doi:10.1002/2016GB005405.
2016	McGuire, A.D., H. Genet, Y. He, S. Stackpoole, D.V. D'Amore, T.S. Rupp, B.K. Wylie, X. Zhou, and Z. Zhu. 2016. Alaska Carbon Balance. Chapter 9 (pages 189-196) in Z. Zhu and A.D. McGuire, eds., Baseline and projected future carbon storage and greenhouse-gas fluxes in ecosystems of Alaska. U.S. Geological Survey Professional Paper 1826, 196 p., http://dx.doi.org/10.3133/pp1826.
2016	McGuire, A.D., T.S. Rupp, T. Kurkowski, and S. Stackpoole. 2016. Introduction. Chapter 1 (pages 5-16) in Z. Zhu and A.D. McGuire, eds., Baseline and projected future carbon storage and greenhouse-gas fluxes in ecosystems of Alaska. U.S. Geological Survey Professional Paper 1826, 196 p., http://dx.doi.org/10.3133/pp1826.
2016	Nicolsky, D. J., Romanovsky, V. E., Panda, S. K., Marchenko, S. M., & Muskett, R. R. (2016). Applicability of the ecosystem type approach to model permafrost dynamics across the Alaska North Slope. Journal of Geophysical Research.
2016	Olefeldt, D., S. Goswami, G. Grosse, D. Hayes, G. Hugelius, P. Kuhry, A.D. McGuire, V.E. Romanovsky, A.B.K. Sannel, E.A.G. Schuur, and M.R. Turetsky. 2016. Circumpolar distribution and carbon storage of thermokarst landscapes. Nature Communications 7:13043, 11 pages, doi:10.1038/ncomms13043.

2016	Noetzli, J., H. H. Christiansen, M. Gugliemin, V. E. Romanovsky, N. I. Shiklomanov, S. L. Smith, and L. Zhao, 2016: [Global Climate] Cryosphere, Permafrost thermal state [in "State of the Climate in 2015"]. Bull. Amer. Meteor. Soc., Vol. 97, No. 8, S20-S22, 2016.
2016	Park, T., S. Ganguly, H. Tømmervik, E.S. Euskirchen, K.-A. Høgda, S.R. Karlsen, V. Brovkin, R.R. Nemani, R.B. Myneni. 2016. Changes in growing season duration and productivity of northern vegetation inferred from long-term remote sensing data. Environmental Research Letters.
2016	Peng, S., P. Ciais, G. Krinner, T. Wang, I. Gouttevin, A.D. McGuire, D. Lawrence, E. Burke, X. Chen, B. Decharme, C. Koven, A. MacDougall, A. Rinke, K. Saito, W. Zhang, R. Alkama, T.J. Bohn, C. Delire, T. Hajima, D. Ji, D.P. Lettenmaier, P.A. Miller, J.C. Moore, B. Smith, T. Sueyoshi. 2016. Simulated high-latitude soil thermal dynamics during the past 4 decades. The Cryosphere 10:179-192, doi:10.5194/tc-10-179-2016.
2016	Romanovsky, V. E., S. L. Smith, K. Isaksen, N. I. Shiklomanov, D. A. Streletskiy, A. L. Kholodov, H. H. Christiansen, D. S. Drozdov, G. V. Malkova, and S. S. Marchenko, 2016: [The Arctic] Terrestrial Permafrost [in "State of the Climate in 2015"]. Bull. Amer. Meteor. Soc., Vol. 97, No. 8, S149-S152, 2016
2016	Ueyama, M., N. Tahara, H. Iwata, E.S. Euskirchen, H. Ikawa, H. Koyayashi, H. Nagano, T. Nakai, Y. Harazono 2016. Optimization of a biochemical model with eddy covariance measurements in black spruce forests of Alaska for estimating CO_2 fertilization effects. Agricultural and Forest Meterology. 222. 98-111. doi: 10.1016/j.agrformet.2016.03.007.
2016	Wang, W., A. Rinke, J.C. Moore, D. Ji, X. Cui, S. Peng, D.M. Lawrence, A.D. McGuire, E.J. Burke, X. Chen, B. Decharme, C. Koven, A. MacDougall, K. Saito, W. Zhang, R. Alkama, T.J. Bohn, P. Ciais, C. Delire, I. Gouttevin, T. Hajima, G. Krinner, D.P. Lettenmaier, P.A. Miller, B. Smith, T. Sueyoshi, and A.B. Sherstiukov. Evaluation of air-soil temperature relationships simulated by land surface models during winter across the permafrost region. The Cryosphere 10:1721-1737, doi:10.5194/tc-10-1721-2016.
2016	Xu, X., W.J. Riley, C.D. Koven, D.P. Billesbach, R.Y.W. Chang, R.Commane, E.S. Euskirchen et al. 2016. A multi-scale comparison of modeled and observed seasonal methane cycles in northern wetlands. Biogeosciences.
2016	Zhou, X., S.A. Schroder, A.D. McGuire, and Z. Zhu. 2016. Forest inventory-based analysis and projections of forest carbon stocks and changes in Alaska coastal forests. Chapter 4 (pages 77-94) in Z. Zhu and A.D. McGuire, eds., Baseline and projected future carbon storage and greenhouse-gas fluxes in ecosystems of Alaska. U.S. Geological Survey Professional Paper 1826, 196 p., http://dx.doi.org/10.3133/pp1826.
2016	Zhu, Z., and McGuire, A.D., eds. 2016. Baseline and projected future carbon storage and greenhouse-gas fluxes in ecosystems of Alaska. U.S. Geological Survey Professional Paper 1826, 196 p., http://dx.doi.org/10.3133/pp1826.

4.3. CONFERENCE PRESENTATIONS

Year	Meeting	Title	Authors
2011	Argonne National Laboratory, Chicago, Illinois	DOS-TEM Modeling Perspective. Workshop to identify data needs for improving model representations of soil carbon responses to climate change in permafrost regions	McGuire, A.D.
2011	Fall Meeting of the American Geophysical Union, San Francisco, California	An assessment of the carbon balance of Arctic tundra: Comparisons among observations, process models, and atmospheric inversions	McGuire, A.D., T.R. Christensen, D.J. Hayes, A. Heroult, J.S. Kimball, C. Koven, P. Lafleur, P. Miller, W.C. Oechel, S. Sitch, and M.D. Williams
2011	Fall Meeting of the American Geophysical Union, San Francisco, California	Changing sources of respiration between a black spruce forest and themokarst bog	Waldrop, M.P., J. McFarland, C.I. Czimczik, E.S. Euskirchen, T. Amendolara, G.J. Scott, M.R. Turetsky, J.W. Harden, and A.D. McGuire
2011	Fall Meeting of the American Geophysical Union, San Francisco, California	Controls on ebullition and methane emissions in Alaskan peatlands experiencing permafrost thaw	Klapstein, S.J., M.R. Turetsky, A.D. McGuire, J.W. Harden, and J.M. Waddington
2011	Fall Meeting of the American Geophysical Union, San Francisco, California	Controls on ecosystem respiration in a peat plateau and adjacent collapse formations in interior Alaska	McConnell, A.D. McGuire, J.W. Harden, and M.R. Turetsky
2011	Fall Meeting of the American Geophysical Union, San Francisco, California	Effects of future warming and fire regime change on boreal soil organic horizons and permafrost dynamics in interior Alaska	F. Yuan, A.D. McGuire, S. Yi, E.S. Euskirchen, T.S. Rupp, A.L. Breen, T. Kurkowski, E.S. Kasischke, and J.W. Harden
2011	Fall Meeting of the American Geophysical Union, San Francisco, California	Feedbacks between climate, fire severity, and differential permafrost degradation in Alaskan black spruce forests – implications for carbon cycling	Kasishke, E.S., E.S. Kane, J.A. O'Donnell, N.L. Christensen, S.R. Mitchell, M.R. Turetsky, D.J. Hayes, E. Hoy, K.M. Barrett, A.D. McGuire, and F. Yuan
2011	Fall Meeting of the American Geophysical Union, San Francisco, California	Modeling the production and transport of methane in an Alaska rich fen peatland	Fan, Z., A.D. McGuire, J.W. Harden, and M.R. Turetsky
2011	Fall Meeting of the American Geophysical Union, San Francisco, California	Quantifying CO_2 fluxes across a gradient of permafrost in boreal Alaska	Euskirchen, E.S., C. Edgar, M.R. Turetsky, J.W. Harden, and A.D. McGuire
2011	Fall Meeting of the American Geophysical Union, San Francisco, California	Reconciling estimates of the contemporary North American carbon balance among an inventory-based approach, terrestrial biosphere models, and atmospheric inversions	Hayes, D.J., D.P. Turner, G. Stinson, A.D. McGuire, Y. Wei, T.O. West, L.S. Heath, B.H. de Jong, B.G. McConkey, R. Birdsey, W.A. Kurz, A.R. Jacobson, D.N. Huntzinger, Y. Pan, W.M. Post, and R.B. Cook
2011	Fall Meeting of the American Geophysical Union, San Francisco, California	The importance of representing interactions among permafrost dynamics, soil warming, and fire in modeling soil carbon responses of northern high latitude terrestrial ecosystems to climate change	McGuire, A.D.
2011	Fall Meeting of the American Geophysical Union, San Francisco, California	Vulnerability of permafrost carbon research coordination network	E.A. Schuur, A.D. McGuire, J. Canadell, J.W. Harden, P. Kuhry, V.E. Romanovsky, M.R. Turetsky, and C. Schadel
2011	GreenCyclesII and DEFROST Conference on Ocean-Land Interactions at High Latitudes. Nuuk, Greenland	An assessment of the carbon balance of arctic tundra: Comparisons among observations, process models, and atmospheric inversions	McGuire, A.D.
2011	The Third Santa Fe Conference on Global and Regional Climate Change. Santa Fe, NM.	Quantifying CO_2 fluxes across gradients of permafrost and soil moisture in boreal and arctic Alaska	Euskirchen, E.S., M.S. Bret-Harte, C. Edgar, J.W. Harden, A.D. McGuire, G. Shaver, M.R. Turetsky
2012	Alaska Cooperative Fish & Wildlife Research Unit Annual Review. Fairbanks, Alaska	The Alaska Integrated Ecosystem Model	Breen, A. L., T. S. Rupp, D. McGuire, V. Romanovsky, E. Euskirchen & S. Marchenko

2012	Annual Meeting of the European Geophysical Union. Vienna, Austria	Vulnerability of permafrost carbon research coordination network	Schädel, C., E.A.G. Schuur, A.D. McGuire, J. Canadell, J. Harden, P. Kuhry, V. Romanovsky, and M. Turetsky
2012	Fall Meeting of the American Geophysical Union, San Francisco, CA	Identification of previously unrecognized tundra fire events on the Arctic Slope of Alaska	Jones, B. M., A. Breen, B. Gaglioti, D. H. Mann, M. L. Kunz, D. Selkowitz, G. Grosse, C. D. Arp, P. E. Higuera, D. Verbyla, V. E. Romanovsky & D. A. Walker.
2012	Fall Meeting of the American Geophysical Union, San Francisco, California	Carbon balance and greenhouse gas fluxes in a thermokarst bog in interior Alaska: Positive and negative feedbacks from permafrost thaw	Waldrop, M.P., J. McFarland, E.S. Euskirchen, M.R. Turetsky, J.W. Harden, K. Manies, M. Jones, and A.D. McGuire
2012	Fall Meeting of the American Geophysical Union, San Francisco, California	Influence of changes in wetland inundation extent on net fluxes of carbon dioxide and methane in northern latitudes from 1993 to 2004	Zhuang, Q., X. Zhu, C. Prigent, J.M. Melillo, A.D. McGuire, R.G. Prinn, and D.W. Kicklighter
2012	Fall Meeting of the American Geophysical Union, San Francisco, California	Linking vegetation composition to geomorphic units in a polygonal tundra landscape: A framework for improving estimates of plant functional type coverage in ecosystem models	Sloan, V.L., C. Iversen, J. Childs, E.S. Euskirchen, A.D. McGuire, and R.J. Norby
2012	Fall Meeting of the American Geophysical Union, San Francisco, California	Methane emission through diffusion and ebullition in thaw wetlands in interior Alaska	Johnston, C.E., S.A. Ewing, R.K. Varner, J.W. Harden, M.R. Turetsky, and A.D. McGuire
2012	Fall Meeting of the American Geophysical Union, San Francisco, California	Modeling leaf phenology variation by groupings within and across ecosystems in northern Alaska	Euskirchen, E.S., T.,B. Carman, and A.D. McGuire
2012	Fall Meeting of the American Geophysical Union, San Francisco, California	Modeling the effects of fire severity on soil organic horizons and forest composition in interior Alaska	Genet, H., K.M. Barrett, J.F. Johnstone, A.D. McGuire, F. Yuan, E.S., Euskirchen, E.S. Kasischke, S.T. Rupp, and M.R. Turetsky
2012	Fall Meeting of the American Geophysical Union, San Francisco, California	Modeling thermokarst dynamics in Alaska ecosystems	Zhang, Y. A.D. McGuire, H. Genet, W.R. Bolton, V.E. Romanovsky, G. Grosse, M.T. Jorgenson
2012	Fall Meeting of the American Geophysical Union, San Francisco, California	Permafrost degradation and organic layer thickening over a climate gradient in a discontinuous permafrost region	Johnson, K.D., J.W. Harden, A.D. McGuire, F. Yuan, and M. Clark
2012	Fall Meeting of the American Geophysical Union, San Francisco, California	The Alaska Integrated Ecosystem Model: An interdisciplinary tool to assess the responses of natural resources in Alaska to climate change	McGuire, A.D., S.T. Rupp, A. Bennett, W.R. Bolton, A. Breen, E.S. Euskirchen, T. Kurkowski, S.S. Marchenko, V.E. Romanovsky, M.P. Waldrop, and F. Yuan
2012	Fall Meeting of the American Geophysical Union, San Francisco, California	The effects of forest fire on the frozen soil thermal state	Jafarov, E.E., H. Genet, V.E. Romanovsky, A.D. McGuire, and S.S. Marchenko
2012	Fall Meeting of the American Geophysical Union, San Francisco, California	The impact of lower sea ice extent on arctic greenhouse gas exchange	Parmentier, F.W., T.R. Christensen, L. Sorensen, S. Rysgaard, A.D. McGuire, P.A. Miller, and D.A. Walker
2012	Fall Meeting of the American Geophysical Union, San Francisco, California	The impact of permafrost thaw on land-atmosphere greenhouse gas exchange in recent decades over the northern high latitudes	Hayes, D.J., D.W. Kicklighter, A.D. McGuire, M. Chen, Q. Zhuang, J.M. Melillo, and S.D. Wullschleger
2012	NASA Arctic Boreal Vulnerability Experiment (ABoVE) Workshop. Boulder, Colorado	Importance of Research on Climate Change in the Arctic-Boreal Region	McGuire, A.D.
2012	Tenth International Conference on Permafrost. Salekhard, Russia	Vulnerability of permafrost carbon research coordination network	Schädel, C., A.D. McGuire, J. G. Canadell, J.W. Harden, P. Kuhry, V. E. Romanovsky, M. R. Turetsky, and E.A.G. Schuur
2013	16th International Boreal Forest Research Association Conference, Edmonton, Alberta, Canada	Modeling the effects of fire severity on soil organic horizons and its effects on permafrost and vegetation composition in Interior Alaska	Genet H., K. Barrett, A.D. McGuire, E.S. Kasischke, M. Turetsky, S. Rupp, E.S. Euskirchen, and F.M. Yuan
2013	16th International Boreal Forest Research Association Conference, Edmonton, Alberta, Canada	Modeling thermokarst dynamics in Alaskan ecosystems	Zhang, Y., H. Genet, A.D. McGuire, W.R. Bolton, V. Romanovsky, G. Grosse, and T. Jorgenson

2013	16th International Boreal Forest Research Association Conference, Edmonton, Alberta, Canada	Multi-factor analysis of the forces driving carbon dynamics in the North American Boreal Forest over recent decades	Hayes, D., G. Stinson, W. Kurz and A.D. McGuire
2013	16th International Boreal Forest Research Association Conference, Edmonton, Alberta, Canada	Patterns in and controls over CO_2 fluxes across a gradient of permafrost thaw in boreal Alaska	Euskirchen, E.S., C. Edgar, M.R. Turetsky, M. Waldrop, J.W. Harden, and A.D. McGuire
2013	Annual Meeting of the Ecological Society of America, Minneapolis, Minnesota	A regionalization approach to study vulnerability of Pan-Arctic permafrost stock to climate change	Goswami, S., D.J. Hayes, P. Kuhry, G. Hugelius, C. Schaedel, D. Olefeldt, G. Grosse, G. Chen, A. Lewkowicz, V. Romanovsky, S. Zubrzycki, S. Gruber, J. Vonk, A.D. McGuire, and E.A.G. Schuur
2013	Annual Meeting of the Ecological Society of America, Minneapolis, Minnesota	Model simulations driven by paleo-forcing data reveal large and rapid responses of carbon storage to boreal fire-regime shifts	Kelly, R., H. Genet, A.D. McGuire, and F.S. Hu
2013	Annual Meeting of the Ecological Society of America, Minneapolis, Minnesota	Vegetation dynamics in a changing Arctic: Improved biogeochemistry response to warming climate through a detailed representation of leaf phenology	Euskirchen, E., T.B. Carman, and A.D. McGuire
2013	Annual Meeting of the European Geophysical Union, Vienna, Austria	The impact of a low sea ice extent on arctic greenhouse gas exchange	Parmentier, F-J., T.R. Christensen, L.L. Sorensen, S. Rysgaard, A.D. McGuire, P.A. Miller, and D.A. Walker
2013	Arctic Science Summit Week, Krakow, Poland	Tundra fire and vegetation dynamics: Simulating the effects of climate change on fire regimes in Arctic ecosystems. The Changing North: Predictions and Scenarios Session	Breen, A. L., A. Bennett, R. E. Hewitt, A. Springsteen, M. Lindgren, T. N. Hollingsworth & T. S. Rupp
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	A comparison in postfire ecosystem structure between two Alaska Arctic regions.	T. N. Hollingsworth; M. C. Mack; A. L. Breen
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Application of a catchment characterization hydrologic model for exploring parameter sensitivities in a boreal forest, discontinuous permafrost ecosystem	D. Morton; W. R. Bolton; J. Young; L. D. Hinzman
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Biomass and production of tundra vegetation under three eddy covariance towers at Imnavait Creek, Alaska	M. S. Bret-Harte; E. S. Euskirchen; C. Edgar; D. C. Huebner; K. Okano; C. L. Tucker; H. Genet; P. M. Ray; G. R. Shaver
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Challenges for understanding the combined impacts of climate change and the 2001-2010 fires on carbon cycling in Alaskan boreal forests (Invited)	E. S. Kasischke; H. D. Alexander; K. Barrett; H. Genet; S. J. Goetz; J. W. Harden; E. Hoy; J. F. Johnstone; T. Jorgenson; E. S. Kane; M. Kavenskiy; M. C. Mack; A. D. McGuire; S. R. Mitchell; J. A. O'Donnell; M. Turetsky
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Challenges in Modeling Disturbance Regimes and Their Impacts in Arctic and Boreal Ecosystems (Invited)	A. D. McGuire; T. S. Rupp; W. Kurz
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Characterization of an Active Thermal Erosion Site, Caribou Creek, Alaska	R. Busey; W. R. Bolton; J. E. Cherry; L. D. Hinzman
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Effects of permafrost thaw on nitrogen availability and plant nitrogen acquisition in Interior Alaska	R. Finger; E. S. Euskirchen; M. Turetsky
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Evaporation Dynamics of Moss and Bare Soil in Boreal Forests	S. Dempster; J. M. Young; C. G. Barron; W. R. Bolton
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	GOSAT CH_4 and CO_2, MODIS Evapotranspiration on the Northern Hemisphere June and July 2009, 2010 and 2011	R. R. Muskett
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Labile carbon concentrations are strongly linked to plant production in Arctic tussock tundra soils	A. Darrouzet-Nardi; M. N. Weintraub; E. S. Euskirchen; H. Steltzer; P. Sullivan
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Last Decade of Changes in Ground Temperature and Active Layer Thickness in the High Canadian Arctic and in Barrow	V. E. Romanovsky; W. Cable; D. A. Walker; K. Yoshikawa; S. S. Marchenko

2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Leaves are just the tip of the iceberg: A review of plant roots in Arctic tundra	C. M. Iversen; V. L. Sloan; P. Sullivan; E. S. Euskirchen; A. D. McGuire; R. J. Norby; A. P. Walker; J. Warren; S. D. Wullschleger
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Microbial communities of the deep unfrozen: Do microbes in taliks increase permafrost carbon vulnerability? (Invited)	M. P. Waldrop; S. Blazewicz; M. Jones; J. W. Mcfarland; J. W. Harden; E. S. Euskirchen; M. Turetsky; J. Hultman; J. Jansson
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Modeled change in carbon balance between 1970-2100 of a polygonal arctic tundra ecosystem near Barrow, Alaska	M. J. Lara; A. D. McGuire; E. S. Euskirchen; V. L. Sloan; C. M. Iversen; R. J. Norby; H. Genet; Y. Zhang; F. Yuan
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Modeling post-fire vegetation succession and its effect on permafrost vulnerability and carbon balance.	H. Genet; A. D. McGuire; J. F. Johnstone; A. L. Breen; E. S. Euskirchen; M. C. Mack; A. M. Melvin; T. S. Rupp; E. A. Schuur; F. Yuan
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Modeling Thermokarst Dynamics in Alaska Ecosystems: Description of the Predisposition and Initiation/Expansion Sub-models	Y. Zhang; A. D. McGuire; H. Genet; W. R. Bolton; V. E. Romanovsky; G. Grosse; T. Jorgenson; M. Lara
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Paleodata-model integration reveals uncertain boreal forest carbon balance due to rapid recent fire regime change	R. Kelly; H. Genet; D. McGuire; F. Hu
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Simulating carbon and water fluxes at Arctic and boreal ecosystems in Alaska by optimizing the modified BIOME-BGC with eddy covariance data	M. Ueyama; M. Kondo; K. Ichii; H. Iwata; E. S. Euskirchen; D. Zona; A. V. Rocha; Y. Harazono; T. Nakai; W. C. Oechel
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Simulation of Water and Land-surface Feedbacks in a Polygonal Tundra Environment	W. R. Bolton; R. Busey; L. D. Hinzman; S. D. Peckham
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Spatial distribution of thermokarst landforms across Arctic Alaska	L. M. Farquharson; G. Grosse; V. E. Romanovsky; B. M. Jones; C. D. Arp; A. D. McGuire
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	The implications of microbial and substrate limitation for the fates of carbon in different organic soil horizon types: a mechanistically based model analysis	Y. He; Q. Zhuang; J. W. Harden; A. D. McGuire; Z. Fan; Y. Liu
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	The Role Of Disturbance In Driving Carbon Dynamics Across The North American Boreal Forest In Recent Decades	D. J. Hayes; G. Chen; G. Stinson; W. Kurz; A. D. McGuire
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	The Role of Explicitly Modeling Bryophytes in Simulating Carbon Exchange and Permafrost Dynamics of an Arctic Coastal Tundra at Barrow, Alaska	F. Yuan; P. E. Thornton; A. D. McGuire; W. C. Oechel; B. Yang; C. E. Tweedie; A. Rogers; R. J. Norby
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	The Vulnerability of Permafrost Carbon: A Retrospective Analysis of Changes in Permafrost Area and Carbon Storage Simulated by Process-Based Models between 1960 and 2009 (Invited)	A. D. McGuire
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Toward Improved Parameterization of a Meso-Scale Hydrologic Model in a Discontinuous Permafrost, Boreal Forest Ecosystem	A. M. Endalamaw; W. R. Bolton; J. M. Young; D. Morton; L. D. Hinzman
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Tree Water Use May Significantly Impact Boreal Hydrology	J. M. Young; W. R. Bolton
2013	Fall Meeting of the American Geophysical Union, San Francisco, California	Tundra fire and vegetation dynamics: simulating the effect of climate change on fire regimes in Arctic ecosystems	A. L. Breen; A. Bennett; R. Hewitt; T. Hollingsworth; H. Genet; E. S. Euskirchen; T. S. Rupp; A. D. McGuire
2013	Fourth North America Carbon Program All Investigators Meeting, Albuquerque, New Mexico	An assessment of the carbon balance of arctic tundra in North America: Comparisons among observations, process models, and atmospheric inversions	McGuire, A.D., D.J. Hayes, T.R. Christensen, A. Heroult, E.S. Euskirchen, J.S. Kimball, C. Koven, P. Lafleur, P. Miller, W.C. Oechel, P. Peylin, M.D. Williams, and Y. Yi
2013	Fourth North America Carbon Program All Investigators Meeting, Albuquerque, New Mexico	CO_2 and CH_4 fluxes and net C storage following permafrost thaw in interior Alaska	Waldrop, M., J. McFarland, E. Euskirchen, M. Turetsky, J. Harden, K. Manies, M. Jones, and A.D. McGuire

2013	Fourth North America Carbon Program All Investigators Meeting, Albuquerque, New Mexico	Modeling the effects of changes in fire severity on soil organic horizons and forest composition in interior Alaska	Genet, H., K. Barrett, J. Johnstone, A.D. McGuire, F. Yuan, E. Euskirchen, E. Kasischke, S. Rupp, and M. Turetsky
2013	Fourth North America Carbon Program All Investigators Meeting, Albuquerque, New Mexico	Quantifying CO_2 fluxes across a gradient of permafrost thaw in boreal Alaska	Euskirchen, E., C. Edgar, M. Waldrop, M. Turetsky, J. Harden, and A.D. McGuire
2013	Fourth North America Carbon Program All Investigators Meeting, Albuquerque, New Mexico	The impacts of permafrost thaw on land-atmosphere greenhouse gas exchange	Hayes, D., D. Kicklighter, A.D. McGuire, Q. Zhuang, J. Melillo, and S. Wullschleger
2013	Fourth North America Carbon Program All Investigators Meeting, Albuquerque, New Mexico	The Permafrost Regionalization Map (PeRM) for studying the vulnerability of permafrost carbon	Goswami, S., D. Hayes, P. Kuhry, G. Hugelius, A.D. McGuire, and E. Schuur
2013	NGEE-Arctic Workshop: Migrating knowledge across spatial scales to improve climate prediction	Incorporating field data into a high resolution biogeochemistry ecosystem model with dynamic vegetation and organic soil layers.	Euskirchen E.S
2013	Society of American Foresters 2013 National Convention, Charleston, South Carolina	Biodiversity increases individual productivity: Evidence and mechanism	Liang, J., M. Zhou, P. Tobin, and A.D. McGuire
2014	Arctic Change Conference. Ottawa, Ontario	The Integrated Ecosystem Model for Alaska and Northwest Canada: An interdisciplinary decision support tool to inform adaptation to Arctic environmental change	Breen, A. L., A. D. McGuire, T. S. Rupp, E. Euskirchen, S. Marchenko, V. E. Romanovsky & the IEM Team.
2014	European Geophysical Union, Vienna, Austria	Higher methane emissions in regions of sea ice retreat	Parmentier, F.-J.W., W. Zhang, Y. Mi, X. Zhu, P.A. Miller, K. van Huissteden, D. Hayes, Q. Zhuang, A.D. McGuire, and T.R. Christensen
2014	Fall Meeting of the American Geophysical Union, San Francisco, California	An Assessment of Thermokarst Driven Changes in Land Cover of the Tanana Flats Wetland Complex of Alaska from 2009 to 2100 in response to Climate Warming	Yujin Zhang, Helene Genet, Mark Lara, Anthony McGuire, Jennifer Roach, Vijay Patil, Vladimir Romanovsky, William Bolton, Ruth Rutter
2014	Fall Meeting of the American Geophysical Union, San Francisco, California	Arctic Diurnal Land-Surface Temperature Range Changes Derived by NASA MODIS-Terra and -Aqua 2000 through 2012	Reginald Muskett
2014	Fall Meeting of the American Geophysical Union, San Francisco, California	Assessment of Model Estimates of Land-Atmosphere CO_2 Exchange Across Northern Eurasia	Michael Rawlins, Anthony McGuire, John Kimball, Pawlok Dass
2014	Fall Meeting of the American Geophysical Union, San Francisco, California	Changes in Landscape-level Carbon Balance of an Arctic Coastal Plain Tundra Ecosystem Between 1970-2100, in Response to Projected Climate Change	Mark Lara, Anthony McGuire, Eugenie Euskirchen, Helene Genet, Victoria Sloan, Colleen Iversen, Richard Norby, Yujin Zhang, Fengming Yuan
2014	Fall Meeting of the American Geophysical Union, San Francisco, California	Climate Change and the Permafrost Carbon Feedback	Edward Schuur et al
2014	Fall Meeting of the American Geophysical Union, San Francisco, California	Controls on northern wetland methane emissions: insights from regional synthesis studies and the Alaska Peatland Experiment (APEX)	Merritt Turetsky, Eugenie Euskirchen, Claudia Czimczik, Mark Waldrop, David Olefeldt, Zhaosheng Fan, Evan Kane, Anthony McGuire, Jennifer Harden
2014	Fall Meeting of the American Geophysical Union, San Francisco, California	Distributed Permafrost Observation Network in Western Alaska: the First Results	Vladimir Romanovsky, William Cable, Sergey Marchenko, Santosh Panda
2014	Fall Meeting of the American Geophysical Union, San Francisco, California	Higher methane emissions in regions of sea ice retreat	Parmentier, F.J.W., W. Zhang, Y. Mi, X. Zhu, P.A. Miller, J. van Huissteden, D. Hayes, Q. Zhang, A.D. McGuire, and T.R. Christensen
2014	Fall Meeting of the American Geophysical Union, San Francisco, California	Initial Conceptualization and Simulation of Arctic Tundra Landscape Evolution Using the Alaska Thermokarst Model	William Bolton, Vladimir Romanovsky, Anthony McGuire, Guido Grosse, Mark Lara

2014	Fall Meeting of the American Geophysical Union, San Francisco, California	Long-Term Release of Carbon Dioxide from Arctic Tundra Ecosystems in Northern Alaska	Eugenie Euskirchen, Marion Bret-Harte, Colin Edgar, Gaius Shaver
2014	Fall Meeting of the American Geophysical Union, San Francisco, California	Modeled changes in terrestrial C storage on the Arctic coastal plain of Alaska suggest a mid-century 21st shift from C sink to source.	Colin Tucker, Eugenie Euskirchen, Helene Genet, Anthony McGuire, Scott Rupp, Amy Breen, Thomas Kurkowski, Alec Bennett, Gary Kofinas
2014	Fall Meeting of the American Geophysical Union, San Francisco, California	Past and Prospective Carbon Stocks of United States Forests: Implications for Research Priorities and Mitigation Policies	Richard Birdsey, Yude Pan, Anthony McGuire, Fangmin Zhang, Jing Chen
2014	Fall Meeting of the American Geophysical Union, San Francisco, California	Terrestrial ecosystem model performance for net primary productivity and its vulnerability to climate change in permafrost regions	Jianyang Xia et al
2014	Fall Meeting of the American Geophysical Union, San Francisco, California	The Importance of Explicitly Representing Soil Carbon with Depth over the Permafrost Region in Earth System Models: Implications for Atmospheric Carbon Dynamics at Multiple Temporal Scales between 1960 and 2300.	Anthony McGuire
2014	Fall Meeting of the American Geophysical Union, San Francisco, California	The Importance of Permafrost Thaw, Fire and Logging Disturbances as Driving Factors of Historical and Projected Carbon Dynamics in Alaskan Ecosystems	Helene Genet, Yujin Zhang, Anthony McGuire, Yujie He, Kristofer Johnson, David D'Amore, Xiaoping Zhou, Alec Bennett, Amy Breen, Frances Biles, Norman Bliss, Eugenie Euskirchen, Thomas Kurkowski, Neal Pastick, Scott Rupp, Bruce Wylie, Zhiliang Zhu, Qianlai Zhuang
2014	Fall Meeting of the American Geophysical Union, San Francisco, California	The Vulnerability of Permafrost from 1960 to 2300 Based on Simulations of the Process-Based Model GIPL2 Across the Permafrost Region in the Northern Hemisphere: Implications for Soil Carbon Vulnerability	Sergey Marchenko, Dmitry Nicolsky, Vladimir Romanovsky, Anthony McGuire
2014	International Arctic Science Committee, Workshop on 'Quantifying Albedo Feedbacks and their Role in the Mass Balance of the Arctic Cryosphere'. Bristol, UK	Albedo and permafrost feedbacks to climate in high latitude terrestrial ecosystems	Euskirchen, E.S.
2014	National Evolutionary Synthesis Center Workshop, 'Scaling evolution from genomes to ecosystem in peatmoss (Sphagnum), Duke University, Raleigh, NC.	Dynamic vegetation models: Simulating Sphagnum	Euskirchen, E.S.
2014	Third Carbon Pools in Permafrost Regions Workshop. Stockholm, Sweden	Retrospective and future assessments of the vulnerability of permafrost and carbon in the earth system: Comparison of dynamics among process-based models	McGuire, A.D., and Members of the Permafrost Carbon Vulnerability Research Coordination Modeling Working Group
2014	US – International Association of Landscape Ecologists Annual Symposium. Anchorage, Alaska	Century time-scale implications for change in peak growing season carbon flux in ice wedge polygonal tundra on the Barrow, Peninsula	Lara, M., A.D. McGuire, and E.S. Euskirchen
2014	US – International Association of Landscape Ecologists Annual Symposium. Anchorage, Alaska	The Integrated Ecosystem Model (IEM) for Alaska and Northwest Canada: An interdisciplinary tool to assess the responses of natural resources to climate change	McGuire, A.D., T.S. Rupp, A. Breen, E. Euskirchen, and V. Romanovsky
2015	17th International Boreal Forest Research Association Conference, Rovaniemi, Finland	A synthesis of carbon balance of Alaska and projected changes in the 21st Century: Implications for climate policy and carbon management at local, regional, national, and international scales	McGuire, A.D., Helene Genet, and Members of the Alaska Land Carbon Assessment Team
2015	17th International Boreal Forest Research Association Conference, Rovaniemi, Finland	National Greenhouse Gas Inventories in Boreal Forests: The US Experience in Interior Alaska	Woodall, C.W., H.E. Andersen, C. Babcock, B. Cook, G. Domke, H. Genet, A. Gray, K. Johnson, S. Jovan, B. McCune, A.D. McGuire, D. Morton, R. Pattison, S. Ogle, B. Schulz, J. Smith, R. Smith, and A. Swan

2015	68th Canadian Geotechnical Conference and 7th Canadian Permafrost Conference, Quebec City, Quebec, Canada.	Recent synthesis of research on the permafrost carbon feedback	Turetsky, M.R., EAG. Schuur, C. Schadel, A.D. McGuire, D. Olefeldt, and G. Hugelius
2015	Environmental and Engineering Geophysical Society Annual Conference	Application of electrical resistivity tomography in two wetland systems north of the Tanana River, Interior Alaska	Conaway, C., T. Lorenson, C. Johnson, M. Waldrop, A.D. McGuire, M. Turetsky, E. Euskirchen, and P.W. Swarzenski
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	A simplified, data-constrained approach to estimate the permafrost carbon-climate feedback: The PCN Incubation-Panarctic Thermal(PInc-PanTher) Scaling Approach	C. Koven; E. Schuur; C. Schaedel; T. Bohn; E. Burke; G. Chen; X. Chen; P. Ciais; G. Grosse; J. Harden; D. Hayes; G. Hugelius; E. Jafarov; G. Krinner; P. Kuhry; D. Lawrence; A. MacDougall; S. Marchenko; A. McGuire; S. Natali; D. Nicolsky; D. Olefeldt; S. Peng; V. Romanovsky; K. Schaefer; J. Strauss; C. Treat; M. Turetsky
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Active-Layer Soil Moisture Content Regional Variations in Alaska and Russia by Ground-Based and Satellite-Based Methods, 2002 Through 2014	R. Muskett; V. Romanovsky; W. Cable; A. Kholodov
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Assessing the Contributions of Thermokarst and Thermal Erosion in Permafrost Feedbacks to Climate	M. Turetsky; A. McGuire; D. Olefeldt
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Assessment of the permafrost changes in the 21st century and their impact on infrastructure in the Alaskan Arctic	D. Nicolsky; V. Romanovsky; S. Panda; S. Marchenko; R. Muskett
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Detecting and Forecasting Permafrost Degradation in a Warming Climate	V. Romanovsky; W. Cable; A. Kholodov; D. Nicolsky; S. Marchenko; S. Panda; R. Muskett
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Future of Plant Functional Types in Terrestrial Biosphere Models	S. Wullschleger; E. Euskirchen; C. Iversen; A. Rogers; S. Serbin
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Getting to the root of the matter: Landscape implications of plant-fungal interactions for tree migration in Alaska	R. Hewitt; A. Bennett; A. Breen; T. Hollingsworth; D. Taylor; T. Chapin; S. Rupp
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Identifying the main drivers of soil carbon response to climate change in arctic and boreal Alaska.	H. Genet; A. McGuire; Y. He; K. Johnson; B. Wylie; N. Pastick; Q. Zhuang; Z. Zhu
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Improving the assessment of the State of the Carbon Cycle in North America by intergrating inventory- and process- based approaches: A case study for Canada	D. Hayes; C. Smith; G. Chen; W. Kurz; G. Stinson; A. McGuire
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Inclusion of Additional Plant Species and Trait Information in Dynamic Vegetation Modeling of Arctic Tundra and Boreal Forest Ecosystem (Invited)	E. Euskirchen; V. Patil; J. Roach; B. Griffith; A. McGuire
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Initial Conceptualization and Application of the Alaska Thermokarst Model	W. Bolton; M. Lara; H. Genet; V. Romanovsky; A. McGuire
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Merging Field Measurements and High Resolution Modeling to Predict Possible Societal Impacts of Permafrost Degradation	V. Romanovsky; D. Nicolsky: S. Marchenko; W. Cable; S. Panda
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Microbial communities and greenhouse gas production from a thermokarst bog chronosequence: Mechanisms of rapid carbon loss	M. Waldrop; M. Jones; K. Manies; J. Mcfarland; S. Blazewicz; J. Keller; M. Haw; J. Harden; C. Medvedeff; M. Turetsky
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Sensitivity of Residual Soil Moisture Content in VIC Model Soil Property Parameterizations for Sub-arctic Discontinuous Permafrost Watersheds	A. Endalamaw; W. Bolton; L. Hinzman; D. Morton; J. Cable
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Succession Stages of Tundra Plant Communities Following Wildfire Disturbance in Arctic Alaska	A Breen; T. Hollingsworth; M. Mack; B. Jones
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	The Alaska Land Carbon Assessment: Baseline and Projected Future Carbon Storage and Greenhouse-gas Fluxes in Ecosystems of Alaska	A. McGuire; H. Genet; Y. He; S. Stackpoole; D. D'Amore; S. Rupp; B. Wylie; A.; X. Zhou; Z. Zhu

2015	Fall Meeting of the American Geophysical Union, San Francisco, California	The Permafrost Condition from 1960 to 2300 Based on Simulations of the GIPL2 Permfrost Dynamics Model across Eurasia: Implications for Soil Carbon Vulnerability, Infrastructure and Socio-economic Impacts	S. Marchenko; D. Streletskiy; V. Romanovsky; D. McGuire; N. Shiklomanov
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	The Temporal Evolution of Changes in Carbon Storage in the Northern Permafrost Region Simulated by Carbon Cycle Models between 2010 and 2300: Implications for Atmospheric Carbon Dynamics	A. McGuire; D. Lawrence; E. Burke; G. Chen; E. Jafarov; C. Koven; A. MacDougall; D. Nicolsky; S. Peng; A. Rinke
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Thermokarst Rates Intensify Due to Climate Change and Forest Fragmentation in an Alaskan Boreal Forest Lowland	M. Lara; H. Grant; A. McGuire; E. Euskirchen; Y. Zhang; D. Brown; T. Jorgenson; V. Romanovsky; A. Breen; W. Bolton
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Thermokarst terrain: pan-Arctic distribution and soil carbon vulnerability	D. Olefeldt; S. Goswami; G. Grosse; D. Hayes; G. Hugelius; P. Kuhry; A. McGuire; V. Romanovsky; B. Sannel; E. Schuur; M. Turetsky
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Towards a better understanding of the sensitivity of permafrost and soil carbon to climate and disturbance-induced change in Alaska	N. Pastick; T. Jorgenson; B. Wylie; B. Minsley; D. Brown; H. Genet; K. Johnson; A. McGuire; A. Kass; J. Knight
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Using Multiple Soil Carbon Maps Facilitates Better Comparisons with Large Scale Modeled Outputs	K. Johnson; D. D'Amore; N. Pastick; H. Genet; U. Mishra; B Wylie; N. Bliss
2015	Fall Meeting of the American Geophysical Union, San Francisco, California	Variability in the Geographis Distribution of Fires in Interior Alaska Considering Cause, Human Proximity, and Level of Supression	M. Calef; A. Varvak; A. McGuire; T. Chapin
2015	Goldschmidt 2015 Conference. Prague, Czech Republic	Pan-arctic trends in lake and wetland thermokarst: Implications for carbon storage and methane fluxes	Turetsky, M.R., D. Olefeldt, and A.D. McGuire
2015	North American Carbon Program All Scientists Meeting. Washington, DC	The importance of permafrost thaw, fire and logging disturbances as driving factors of historical and projected carbon dynamics in Alaskan upland ecosystems	Genet H., Zhang Y., McGuire A.D., He Y., Johnson K., D'Amore D., Zhou X., Bennett A., Biles F., Bliss N., Breen A., Euskirchen E.S., Kurkowski T., Pastick N., Rupp S., Wylie B., Zhu Z., and Zhuang Q
2015	North American Carbon Program Meeting. Washington, DC	A synthesis of terrestrial carbon balance of Alaska and projected changes in the 21st Century: Implications for climate policy and carbon management at local, regional, national, and international scales	McGuire, A.D., and Members of the Alaska Land Carbon Assessment Team
2015	North American Carbon Program Meeting. Washington, DC	On the integration of inventory- and process- based approaches to determine Canada's full forest carbon budget and the forces that drive it	Hayes, D., G. Chen, W. Kurz, G. Stinson, and A.D. McGuire
2015	North American Carbon Program Meeting. Washington, DC	Representing soil carbon dynamics in global land models to improve future IPCC assessments	Luo, Y., et al. (including A.D. McGuire)
2015	North American Carbon Program Meeting. Washington, DC	The Alaska Forest Disturbance Carbon Tracking System	Loboda, T., Kasischke, E., McGuire, A.D., Genet, H., and Hoy, E
2015	Pacific Islands CSC Hawaii Downscaling Workshop. Honolulu, HI	Choosing and Using Climate Scenarios in Alaska: Implications of "Data Sparse" for Climate Services	Littell, J.S.
2015	Workshop on Traits Methods for Representing Ecosystem Change. Rockville, MD	Plant community dynamics and traits as represented by in the Dynamic Vegetation Module of the Terrestrial Ecosystem Model	Euskirchen, E.S.
2016	14th International Circumpolar Remote Sensing Symposium. Homer, Alaska	A model-data integration framework for NASA-ABoVE: The role of remote sensing in process-based model representation of Arctic ecosystem dynamics.	Hayes, D.J., J.B. Fisher, E.J. Stofferahn, C.R. Schwalm, D.N. Huntzinger, and A.D. McGuire.
2016	Association of American Geographers Annual Meeting. San Francisco, CA	Geographic distribution of fire ignitions and area burned in interior Alaska considering cause, human proximity, and level of suppression	Calef, M.P., A. Varvak, L. DeWilde, A.D. McGuire, and F.S. Chapin III
2016	Ecological Society of America, Fort Lauderdale, FL	No Analog Arctic? Ecological Drought in Northern Ecosystems	Littell, J.S.

2016	Eleventh International Conference on Permafrost. Potsdam, Germany	Comparing permafrost soil carbon pools from coupled earth system models to empirically derived datasets	Hugelius, G., A.D. McGuire, T.J. Bohn, E.J. Burke, S. Chadburn, G. Chen, X. Chen, D.J. Hayes, E.E. Jafarov, C.D. Koven, A.H. MacDougall, S. Peng, and K.M. Schaefer
2016	Eleventh International Conference on Permafrost. Potsdam, Germany	Conceptualization and application of the Alaska Thermokarst Model	Bolton, W.R., M. Lara, H. Genet, V. Romanovsky, A.D. McGuire
2016	Eleventh International Conference on Permafrost. Potsdam, Germany	Diagnostic and model dependent uncertainty of simulated Tibetan permafrost area	Wang, W., A. Rinke, J.C. Moore, X. Cui, D. Ji, Q. Li, N. Zhang, C. Wang, S. Zhang, D.M. Lawrence, A.D. McGuire, W. Zhang, C. Delire, C. Koven, K. Saito, A. MacDougall, E. Burke, and B. Decharme
2016	Eleventh International Conference on Permafrost. Potsdam, Germany	High resolution soil temperature and active layer dataset for estimating rates of permafrost degradation and their impact on ecosystems, infrastructure, CO_2 and CH_4 fluxes and net C storage following permafrost thaw in Alaska and Northwest Canada	Marchenko, S., H. Genet, E. Euskirchen, A.D. McGuire, T.S. Rupp, W.R. Bolton, A. Breen, M. Waldrop, S. McAfee, F. Yuan, Y. Zhang, V. Romanovsky, J. Walsh, T. Kurkowski, M. Lindgren, A. Bennett, M. Leonawicz, T. Carman, A. Floyd, and K. Timm
2016	Eleventh International Conference on Permafrost. Potsdam, Germany	How well do observations, models and experiments represent the circumarctic-scale spatial variability in permafrost carbon vulnerability?	Hayes, D.J., P. Kuhry, S. Goswami, G. Grosse, A.D. McGuire, and E.A.G. Schuur
2016	Eleventh International Conference on Permafrost. Potsdam, Germany	Mapping polygonal tundra geomorphology across the Arctic Coastal Plain of Alaska	Lara, M.J., P. Martin, and A.D. McGuire
2016	Eleventh International Conference on Permafrost. Potsdam, Germany	Modeling landscape vulnerability to thermokarst disturbance in boreal Alaska	Genet, H., M. Lara, W.R. Bolton, A.D. McGuire, V. Romanovsky, and M. Turetsky
2016	Eleventh International Conference on Permafrost. Potsdam, Germany	Quantifying the impact of permafrost dynamics on soil carbon accumulation in response to climate change and wildfire intensification in Alaska	Genet, H., Y. He, A.D. McGuire, Q. Zhuang, Z. Zhu, N. Pastick, B. Wylie, and K. Johnson
2016	Eleventh International Conference on Permafrost. Potsdam, Germany	The Temporal Evolution of Changes in Carbon Storage in the Northern Permafrost Region Simulated by Carbon Cycle Models between 2010 and 2300: Implications for Atmospheric Carbon Dynamics	McGuire, A.D., D. Lawrence, E. Burke, G. Chen, E. Jafarov, C. Koven, A. MacDougall, D. Nicolsky, S. Peng, and D. Ji.
2016	Eleventh International Conference on Permafrost. Potsdam, Germany	Thermokarst rates intensify due to climate change and forest fragmentation in an Alaskan boreal forest lowland. Eleventh International Conference on Permafrost	Lara, M.J., H. Genet, A.D. McGuire, E.S. Euskirchen, Y. Zhang, D.R.N. Brown, M.T. Jorgenson, V. Romanovsky, A. Breen, and W.R. Bolton
2016	Eleventh International Conference on Permafrost. Potsdam, Germany	Upscaling permafrost carbon loss from thermokarst and thermal erosion across the northern permafrost domain	Turetsky, M., A.D. McGuire, and D. Olefeldt
2016	Interagency Arctic Research Policy Committee (IARPC) Wildfire Collaboration Team Meeting	The Alaska Land Carbon Assessment: Baseline and Projected Future Carbon Storage and Greenhouse-gas Fluxes in Ecosystems of Alaska	McGuire, A.D., H. Genet, Y. He, S. Stackpoole, D. D'Amore, T.S. Rupp, B. Wylie, X. Zhou, and Z. Zhu
2016	National Center for Atmospheric Research USACE Alaska Project Development Meeting. Boulder, CO	Climate Information Needs in Alaska: Current Uses, Stakeholder Requests, and Opportunities	Littell, J.S.
2016	The Ecosystem Approach to Management International Conference. Fairbanks, Alaska.	The Integrated Ecosystem Model for Alaska and Northwest Canada: An interdisciplinary decision support tool to inform adaptation to Arctic environmental change	Bolton, W. R., Breen, A.L., A.D. McGuire, T.S. Rupp, E. Euskirchen, S. Marchenko, V. E. Romanovsky, and the IEM Team.

SECTION 5. OUTREACH ACTIVITIES & PRESENTATIONS

Type	Year	Venue / Forum	Title	Author(s)	Link (If applicable)
Presentation	2010	Arctic Landscape Conservation Cooperative	An Integrated Ecosystem Model for Alaska	Breen, A. L., T. S. Rupp, D. McGuire, V. Romanovsky, E. Euskirchen & S. Marchenko	
Presentation	2011	Alaska Fire Science Workshop. Fairbanks, Alaska	Identifying indicators of state change and forecasting future vulnerability in Alaska boreal ecosystems	McGuire, A.D.	
Presentation	2011	Climate Change Seminar Series. University of Alaska Fairbanks, Alaska	Vegetation change in western Alaska	Breen, A. L.	
Webinar	2011	US Geological Survey Land Use and Climate Change Brown Bag Seminar	An Integrated Ecosystem Model for Alaska	Breen, A. L., T. S. Rupp, D. McGuire, V. Romanovsky, E. Euskirchen & S. Marchenko	
Fact Sheet	2012		Alaska Integrated Ecosystem Model Fact Sheet		https://csc.alaska.edu/resource/alaska-integrated-ecosystem-model-fact-sheet
Magazine	2012	Alaska Park Science	Using integrated ecosystem modeling to understand climate change	Gray, S.T., A. Bennett, W.R. Bolton, A.L. Breen, T. Carman, E. Euskirchen, H. Genet, E. Jafarov, J. Jenkins, T. Kurkowski, M. Lindgren, P. Martin, S. McAfee, A.D. McGuire, S. Marchenko, R. Muskett, S. Panda, J. Reynolds, A. Robertson, V. Romanovsky, T.S. Rupp, K. Timm, and Y. Zhang	https://csc.alaska.edu/resource/using-integrated-ecosystem-modeling-understand-climate-change
News Story	2012	Alaska News Nightly	Computer Model To Predict Climate-Driven Ecosystem Changes	Edge, J.	http://www.alaskapublic.org/2012/05/02/alaska-news-nightly-may-2-2012/
Webinar	2012	Western Alaska Landscape Conservation Cooperative	Alaska Integrated Ecosystem Model	D. McGuire, Breen, A. L., T. S. Rupp, V. Romanovsky, E. Euskirchen & S. Marchenko	
Presentation	2012	Denali National Park Summer Science Series	Assessing Responses of Alaska's Ecological Resources to Climate Change	McGuire, A. D.	
Report	2012		2012 Annual Report on the Integrated Ecosystem Model for Alaska and Canada Project		https://csc.alaska.edu/resource/2012-annual-report-integrated-ecosystem-model-alaska-and-canada-project
Webinar	2012	Arctic LCC Webinar	An Integrated Ecosystem Model for Alaska	McGuire, A. D.	

Webinar	2012	Alaska Center for Climate Assessment & Policy Climate Webinar Series	An Integrated Ecosystem Model for Alaska	Breen, A. L., T. S. Rupp, D. McGuire, V. Romanovsky, E. Euskirchen & S. Marchenko	https://accap.uaf.edu/webinar/development-and-application-integrated-ecosystem-model-alaska
Webinar	2012	Arctic Landscape Conservation Cooperative	Alaska Integrated Ecosystem Model: The pilot year	Breen, A. L., T. S. Rupp, D. McGuire, V. Romanovsky, E. Euskirchen & S. Marchenko	
White Paper	2012		Modeling Thermokarst Dynamics in Boreal and Arctic regions of Alaska and Northwest Canada: A White Paper	McGuire, A. D.	https://csc.alaska.edu/resource/modeling-thermokarst-dynamics-boreal-and-arctic-regions-alaska-and-northwest-canada-white
Article	2013	Landscape Conservation Cooperatives in Alaska Quaterly Newsletter	Partner Highlight: Integrated Ecosystem Model for Alaska and Northwest Canada		
Presentation	2014	Climate, Conservation, and Community in Alaska and Northwest Canada	The Integrated Ecosystem Model for Alaska and Northwest Canada: An Interdisciplinary Decision Support Tool to Inform Adaptation to Rapid Environmental Change	Breen, A.	
Presentation	2014	Climate, Conservation, and Community in Alaska and Northwest Canada	Initial Conceptualization of Arctic Tundra Landscape Evolution Using the Alaska Thermokarst Model	Bolton, W.	
Report	2014		Interim Progress Report: Integrated Ecosystem Model for Alaska and Northwest Canada		https://csc.alaska.edu/resource/interim-progress-report-IEM
Video	2014	Climate, Conservation, and Community in Alaska and Northwest Canada Conference	The Integrated Ecosystem Model for Alaska and Northwest Canada: An Interdisciplinary Decision Support Tool to Inform Adaptation to Rapid Environmental Change	Breen, A.	https://vimeo.com/channels/889350/123806424
Video	2014	Climate, Conservation, and Community in Alaska and Northwest Canada Conference	Initial Conceptualization of Arctic Tundra Landscape Evolution Using the Alaska Thermokarst Model	Bolton, W.	https://vimeo.com/channels/889350/121932316
News Story	2015	AK CSC Website News	Four Million Acres Burned, And a Few Questions About Alaska's Future	Timm, K.	https://csc.alaska.edu/news/four-million-acres-burned-and-few-questions-about-alaska%E2%80%99s-future
News Story	2015	USGS Top Story	Four Million Acres Burned, And a Few Questions About Alaska's Future	Timm, K.	https://www2.usgs.gov/blogs/features/usgs_top_story/four-million-acres-burned-and-a-few-questions-about-alaskas-future/
News Story	2015	AK CSC Website News	Scientists predict gradual, prolonged permafrost greenhouse gas emissions	Thoms, M. & Timm, K.	https://csc.alaska.edu/news/scientists-predict-gradual-prolonged-permafrost-greenhouse-gas-emissions
News Story	2015	Fairbanks Daily News Miner	Study: Permafrost 'carbon bomb' unlikely	Robin Wood, FDNM	http://www.newsminer.com/science_and_technology/study-permafrost-carbon-bomb-unlikely/article_96b85a4a-e27a-11e4-9283-4ff44a6ad583.html

News Story	2015	Daily Mail	Microbes eating melting Artic soil will add 'substantial amounts' of carbon to the atmosphere, researchers warn	Associated Press	http://www.dailymail.co.uk/sciencetech/article-3034310/Researchers-say-permafrost-carbon-release-gradual.html#ixzz4JZdp7hKW
News Story	2015	Scientific American	A Stormy Arctic Is the New Normal	Edward Struzik	http://www.scientificamerican.com/article/a-stormy-arctic-is-the-new-normal-excerpt/
News Story	2015	Washington Post	Alaska's terrifying wildfire season and what it says about climate change	Chris Mooney	https://www.washingtonpost.com/news/energy-environment/wp/2015/07/26/alaskas-terrifying-wildfire-season-and-what-it-says-about-climate-change/?utm_term=.b8a924b44826
News Story	2015	Alaska Public Media	Study: Carbon emissions from northern fires likely underestimated	Robert Hannon	http://www.alaskapublic.org/2015/11/04/study-carbon-emissions-from-northern-fires-likely-underestimated/
Presentation	2015	Briefing with NOAA director Kathleen Sullivan prior to President Obama's visit to Alaska		Bhatt, U.	
Presentation	2015	Spring 2015 meeting of the Alaska Climate Change Executive Roundtable. Anchorage, AK	Alaska's Climate Science Center: Portfolio Approach to Understanding Climate Change	Littell, J.S. and S.T. Gray	
Presentation	2015	Alaska Common Ground Forum - Alaska's Changing Climate: Impacts, Policy and Action. Anchorage, AK.	Climate Change and Climate Impacts in Alaska: Need-to-know primer from planet to region	Littell, J.S.	
Presentation	2015	USFWS Conservation Frameworks for Alaska. Anchorage, AK	Climate Data, Projections, and Potential Products for USFWS Conservation Frameworks	Littell, J.S.	
Webinar	2015	Webinar for the LCC Coordinators and other Resource Managers	How can we use climate science to answer land management questions?	McGuire, A.D.	https://csc.alaska.edu/events/iem-webinar
Fact Sheet	2016		Integrated Ecosystem Model for Alaska and Northwest Canada Fact Sheet and Supplement		https://csc.alaska.edu/resource/integrated-ecosystem-model
Illustration	2016		Boreal System Illustration	Timm, K.	https://csc.alaska.edu/resource/boreal-system-illustration
News Story	2016	AK CSC Website News	New report calculates Alaska's greenhouse gas potential	Thoms, M. & Timm, K.	https://csc.alaska.edu/news/new-report-calculates-alaska%E2%80%99s-greenhouse-gas-potential
News Story	2016	Alaska Dispatch News	Melting Alaska may not accelerate climate change as expected, scientists now say	Erica Martinson	http://www.adn.com/alaska-news/environment/2016/06/01/melting-alaska-may-not-accelerate-climate-change-as-expected-scientists-now-say/

Presentation	2016	The Ecosystem Approach to Management International Conference	The Integrated Ecosystem Model for Alaska and Northwest Canada: An interdisciplinary decision support tool to inform adaptation to Arctic environmental change.	Breen, A.L., A.D. McGuire, T.S. Rupp, E. Euskirchen, S. Marchenko, V. E. Romanovsky, and the IEM Team	
Presentation	2016	Interagency Arctic Research Policy Committee (IARPC) Wildfire Collaboration Team Meeting	The Alaska Land Carbon Assessment: Baseline and Projected Future Carbon Storage and Greenhouse-gas Fluxes in Ecosystems of Alaska	McGuire, A.D., H. Genet, Y. He, S. Stackpoole, D. D'Amore, T.S. Rupp, B. Wylie, X. Zhou, and Z. Zhu	
Presentation	2016	Spring 2016 Board of Game / Subsistence Regional Advisory Committees meeting. Anchorage, AK	Climate Change and Impacts on Wildlife in Alaska: Alaska Climate Science Center perspective	Littell, J.S.	
Presentation	2016	Nome Coastal Resilience Workshop. Nome, AK	Climate Change and Landscape Changes in the Nome Region	Littell, J.S.	
Presentation	2016	Alaska Forum on the Environment. Anchorage, AK	A short introduction to climate models: Practical considerations for IARPC Terrestrial Ecosystem	Littell, J.S.	
Video	In Prep		Video highlighting IEM project (under production)	Prince, R. & Timm, K.	

SECTION 6. ACKNOWLEDGMENTS

The Alaska Climate Science Center provided the majority of the funding for this project. We also acknowledge substantial financial support from the Arctic, Western Alaska, and Northwest Boreal LCCs during the course of the project. We thank Philip Martin and Jennifer Jenkins with the Arctic LCC, Karen Murphy and Joel Reynolds with the Western Alaska LCC, Amanda Robertson with the Northwest Boreal LCC, and Stephen Gray and Jeremy Littell with the USGS Alaska Climate Science Center for constructive comments and feedback throughout the project.

We thank Kristen Manies (USGS), Zhiliang Zhu (USGS), Stephen Gray (USGS), Jeremy Littell (USGS), and Joel Reynolds (USFWS) for constructive and helpful comments on earlier drafts of this report.

We acknowledge the World Climate Research Programme's Working Group on Coupled Modelling, which is responsible for CMIP, and we thank the climate modeling groups for producing and making available their model output. For CMIP the U.S. Department of Energy's Program for Climate Model Diagnosis and Intercomparison provides coordinating support and led development of software infrastructure in partnership with the Global Organization for Earth System Science Portals.

SECTION 7. REFERENCES

Breen, A. L., Bennett, A., Hewitt, R. E., Hollingsworth, T. N., Genet, H., Euskirchen, E. S., McGuire, A. D., & Rupp, T. S. (In press). Tundra fire and vegetation dynamics: simulating the effect of climate change on fire regimes in Arctic ecosystems. *Environmental Research Letters Special Issue on Changing Fire Regimes*.

Breen, A., Bennett, A., Kurkowski, T. , Lindgren, M., Schroder, J., Mcguire, A. D., & Rupp, T. S. (In Press). Projecting vegetation and wildfire responses to changing climate and fire management in interior Alaska. *Alaska Fire Science Consortium, Research Summary 2016-1*. Fairbanks, AK: University of Alaska Fairbanks.

Chapin, F. S., III, Sturm, M., Serreze, M. C., McFadden, J. P., Key, J. R., Lloyd, A. H., McGuire, A. D., Rupp, T. S., Lynch, A. H., Schimel, J. P., Beringer, J., Chapman, W. L., Epstein, H. E., Euskirchen, E. S., Hinzman, L. D., Jia, G., Ping, C. L., Tape, K. D., Thompson, C. D. C., Walker, D. A., & Welker, J. M. (2005). Role of land-surface changes in Arctic summer warming. *Science,* 310, 657–660. doi:10.1126/science.1117368

Euskirchen, E. S., McGuire, A. D., & Chapin, F. S., III. (2007). Energy feedbacks of northern high-latitude ecosystems to the climate system due to reduced snow cover during 20th century warming. *Global Change Biology,* 13, 2425–2438. doi:10.1111/j.1365-2486.2007.01450.x

CAVM Team. (2003). *Circumpolar Arctic Vegetation Map (1:7,500,000 scale)*, Conservation of Arctic Flora and Fauna (CAFF) Map No. 1. U.S. Fish and Wildlife Service, Anchorage, Alaska. ISBN: 0-9767525-0-6, ISBN-13: 978-0-9767525-0-9

Euskirchen, E. S., Edgar, C., Turetsky, M.R., Waldrop, M.P., & Harden, J.W. (2014). Differential response of carbon fluxes to climate in three peatland ecosystems that vary in the presence and stability of permafrost. *Journal of Geophysical Research: Biogeosciences,* 119, 1576–1595, doi:10.1002/2014JG002683

Euskirchen, E. S., Bennett, A., Breen, A., Genet, H., Lingren, M., Kurkowski, T., McGuire, A.D., & Rupp, S.T. (In press). Consequences of changes in vegetation and snow cover for climate feedbacks in Alaska and northwest Canada. E*nvironmental Research Letters Special Issue on Changing Fire Regimes*.

Fan, Z., McGuire, A. D., Turetsky, M.R., Harden, J.W., Waddington, J.M. & Kane, E.S. (2013). The response of soil organic carbon of a rich fen peatland in interior Alaska to projected climate change. *Global Change Biology,* 19, 604-620. doi:10.1111/gcb.12041

Finger, R. A., Turetsky, M. R., Kielland, K., Ruess, R.W., Mack, M.C., & Euskirchen, E.S. (2016). Effects of permafrost thaw on nitrogen availability and plant-soil interactions in a boreal Alaskan lowland. *Journal of Ecology*, 104(6), 1542–1554. doi: 10.1111/1365-2745.12639

Genet, H., McGuire, A. D., Barrett, K., Breen, A. L., Euskirchen, E. S., Johnstone, J. F., Kasischke, E. S., Melvin, A. M., Bennet, A., Mack, M. C., Rupp, T. S., Schuur, A. E. G., Turetsky, M. R., & Yuan, F. (2013). Modeling the effects of fire severity and climate warming on active layer thickness and soil carbon storage of black spruce forests across the landscape in Interior Alaska. *Environmental Research Letters*, 8, 1-13. doi: 045016. doi:10.1088/1748-9326/8/4/045016

Genet, H., He, Y., McGuire, A. D., Zhuang, Q., Zhang, Y., Biles, F., D'Amore, D. V., Zhou, K., & Johnson, K. D. (2016). Terrestrial Carbon Modeling: Baseline and Projections in Upland Ecosystems In: Zhiliang, Z. and A. D. McGuire (Eds.) *Baseline and projected future carbon storage and greenhouse gas fluxes in ecosystems in Alaska*. USGS Professional Paper 1826.

Harris, I., Jones, P., Osborn, T., & Lister, D. (2014). Updated high-resolution grids of monthly climatic observations the cru ts3.10 dataset. *International Journal of Climatology*, 34(3), 623–642.

He, Y., Genet, H., McGuire, A. D., Zhuang, Q., Wylie, B., & Zhang, Y. (2016). Wetland Carbon Dynamics in Alaska from 1950 to 2099. In Zhiliang, Z. & McGuire, A. D. (Eds.) *Baseline and projected future carbon storage and greenhouse gas fluxes in ecosystems in Alaska.* USGS Professional Paper 1826.

Hewitt, R. E., Bennett, A. P., Breen, A. L., Hollingsworth, T. N., Taylor, D. L., Chapin, F. S., III, & Rupp, T. S. (2015). Getting to the root of the matter: Landscape implications of plant-fungal interactions for tree migration in Alaska. *Landscape Ecology, 31(4), 895–911.* doi: 10.1007/s10980-015-0306-1

Homer, C., Dewitz, J., Fry, J., Coan, M., Hossain, N., Larson, C., Herold, N., McKerrow, A., VanDriel, J.N., & Wickham, J. (2007). Completion of the 2001 National Land Cover Database for the Conterminous United States. *Photogrammetric Engineering and Remote Sensing*, 73(4), 337-341.

IPCC. (2014). Climate Change 2014: Synthesis Report. In R.K. Pachauri and L.A. Meyer (eds.) *Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Geneva, Switzerland, 151 pp.

IPCC. (2013). Summary for Policymakers. In Stocker, T. F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., Bex, V., & Midgley, P. M. (Eds.) *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jafarov, E. E., Marchenko, S. S. & Romanovsky, V. E. (2012). Numerical Modeling of Permafrost Dynamics in Alaska Using a High Spatial Resolution Dataset. *The Cryosphere,* 6, 613-624. doi:10.5194/tc-6-613-2012

Jorgenson, M., Kanevskiy, M., Shur, Y., Grunblatt, J., Ping, C., & Michaelson, G. (2014). *Permafrost database development, characterization and mapping for Northern Alaska, Final report.* Prepared for U.S. Fish and Wildlife Service, Arctic Landscape Conservation Cooperative, Anchorage, AK, 49 pp.

Jorgenson, M.T. & Osterkamp, T. E. (2005). Response of boreal ecosystems to varying modes of permafrost degradation. *Canadian Journal of Forest Research*, 35, 2100-2111.

Jorgenson, T. & Heiner, M. (2004). *Ecosystems of Northern Alaska*, Map 1:1,200,000 scale, ABR, Inc. and The Nature Conservancy, Anchorage, Alaska, poster.

Jorgenson, M. T., Racine, C. H., Walters, J. C. & Osterkamp, T. E. (2001). Permafrost degradation and ecological changes associated with a warming climate in central Alaska. *Climatic Change*, 48, 551-579.

Lara, M. J., Genet, H., McGuire, A. D., Euskirchen, E. S., Zhang, Y., Brown, D. R. N., Jorgenson, M. T., Romanovsky, V., Breen, A., & Bolton, W. R. (2016). Thermokarst rates intensify due to climate change and forest fragmentation in an Alaskan boreal forest lowland. *Global Change Biology*, 22(2), 816–829. doi: 10.1111/gcb.13124

Liljedahl, A. K, Hinzman, L.D. & Schulla, J. (2012). Vol. 1: International Contributions. In Hinkel K. M. (Ed.) *Tenth International Conference on Permafrost*. TheNorthern Publisher, Salekhard, Russia, pp 231-236.

Malone, T., Liang, J., & Packee, C. (2009). *Cooperative Alaska Forest Inventory*. Portland, Oregon.

Marchenko, S., Romanovsky, V. & Tipenko, G. (2008). Numerical Modeling of Spatial Permafrost Dynamics in Alaska. In Kane, D. & Hinkel, K. (Eds.) *Proceedings of the Ninth International Conference on Permafrost.* University of Alaska Fairbanks, June 29 - July 3, 2008, pp 1125-1130.

Meehl, G. Covey, A., C., Delworth, T., Latif, M., McAvaney, B., Mitchell, J. F. B., Stouffer, R. J., & Taylor, K. E. (2007). The WCRP CMIP3 multi-model dataset: A new era in climate change research. *Bulletin of the American Meteorological Society,* 88, 1383-1394.

Mi, Y., McGuire, A.D., Fan, Z., Manies, K., Euskirchen, E. S.,Waldrop, M., Genet, H., Harden, J., Churchill, A., Romanovsky, V. & Turetsky, M. (In preparation.) The potential response of C storage and atmospheric exchange dynamics in a collapse-scar bog ecosystem to projected climate change.

Moss, R. H., et al. (2008), *Towards New Scenarios for Analysis of Emissions, Climate Change, Impacts, and Response Strategies*, Intergovernmental Panel on Climate Change. Geneva, Switzerland. pp 132.

Nakicenovic, N., Alcamo, J., Davis, G., Vries, B. de, Fenhann, J., Gaffin, S., Gregory, K., Grübler, A., Jung, T.Y., Kram, T., Rovere, E.L.L., Michaelis, L., Mori, S., Morita, T., Pepper, W., Pitcher, H., Price, L., Riahi, K., Roehrl, A., Rogner, H.-H., Sankovski, A., Schlesinger, M., Shukla, P., Smith, S., Swart, R., Rooijen, S. van, Victor, N., Dadi, Z., (2000). *Special Report on Emissions Scenarios.* In: Nakicenovic, N. & Swart, R. (Eds). Cambridge University Press.

Nicolsky, D.J., Romanovsky, V.E. & Panteleev, G.G. (2009). Estimation of soil thermal properties using in-situ temperature measurements in the active layer and permafrost. *Cold Regions Science and Technology*, 55, 120-129.

Olefeldt, D, Euskirchen, E.S., Harden, J., Kane, E., McGuire, A.D., Waldrop, M., & Turetsky, M.R. (In review). Greenhouse gas fluxes and their cumulative response to inter-annual variability and experimental manipulation of the water table position in a boreal fen. *Global Change Biology.*

Roach, J., Griffith B., & Verbyla D. (2013). Landscape influences on climate-related lake shrinkage at high latitudes. *Global Change Biology,* 19, 2276–2284.

Rupp, T. S., Duffy, P., Leonawicz, M., Lindgren, M., Breen, A., Kurkowski, T., Floyd, A., Bennett, A. & Krutikov, L. (2016). Climate Scenarios, Land Cover, and Wildfire in Alaska. In Zhiliang, Z. & McGuire, A. D. (Eds.) *Baseline and projected future carbon storage and greenhouse gas fluxes in ecosystems in Alaska.* USGS Professional Paper 1826, pp. 17-52.

Taylor, K.E., Stouffer, R.J. & Meehl, G. A. (2012). An Overview of CMIP5 and the Experiment Design. *Bulletin of the American Meteorological Society,* 93, 485–498. doi: 10.1175/BAMS-D-11-00094.1

Walsh, J., Chapman, W., Romanovsky, V. R., Christensen, J., & Stendel, M. (2008). Global climate model performance over Alaska and Greenland. *Journal of Climate*, 21(23), 6156–6174.

Yuan, F. –M, Yi, S.-H., McGuire, A. D., Johnson, K. D., Liang, J.-J., Harden, J. W., Kasischke, E. & Kurz, W.A. (2012). Assessment of historical boreal forest carbon dynamics in the Yukon River Basin: Relative roles of climate warming and fire regime changes. *Ecological Applications,* 22, 2091-2109.

Zhuang, Q., Melillo, J. M., Kicklighter, D. W., Prinn, R. G., McGuire, A. D., Steudler, P. A., Felzer, B. S., & Hu, S. (2004). Methane fluxes between terrestrial ecosystems and the atmosphere at northern high latitudes during the past century: A retrospective analysis with a process-based biogeochemistry model. *Global Biogeochemical Cycles*, 18, GB3010. doi:10.1029/2004GB002239

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